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M. GIAFFE'S MODIFICATION OF EDISON'S CARBON TELEPHONE.

THE engraving represents a new form of Edison's carbon telephone, devised by M. Giaffe. The base of the instrument is supported upon two pieces of rubber tubing, and the short pedestal contains a carbon pole to which is attached the square carbon plate. This plate rests against a carbon pencil contained in the metal tube, which is adjustable on the tall standard. The carbon plate and pencil are placed in the same circuit with a receiving instrument, which is in fact an ordinary Bell telephone. A current of light intensity is sufficient to transmit the sounds through several miles of wire.

The instrument is wonderfully sensitive. An ant walking across the carbon plate produces a sound in the receiving instrument like the running of children on a sanded floor. Scratching the surface of the carbon with a piece of paper makes a sound like the grating of iron, and rubbing the barb of a feather on the carbon makes in the receiver a sound like hammers.

Blowing on the plate produces a sound like the rushing of waters.

Conversation in any part of a room in which the telephone is placed can be plainly heard in the receiving instrument.

It amplifies sounds in a marvelous manner, and is said to be to the ear what the microscope is to the eye. We take the engraving from *Illustration*.

LABORATORY NOTES.

By JOHN G. MCKENDRICK.

1. *Carl Zeiss' New Oil Immersion Lens.*—This is a $\frac{1}{18}$th-objective, on the immersion system, in which the fluid used is oil of cedar-wood. For amount of light, clearness of definition, resolving power, and flatness of field, it is superior to any lens I have worked with. For use in histological observation, it does not require any special arrangement of light. In examining such objects as blood-corpuscles or salivary cells with very high powers it is of great advantage to be able to use cover-glasses of ordinary thickness, and to have a serviceably-working distance. This is secured by Zeiss' lens. I have found that, with ordinary Nos. 6 and 7 Hartnack-objectives, more light is obtained by using them as immersion lenses with a drop of equal parts of oil of cedar-wood and olive oil. The method of using fluids of high refractive index, on the immersion principle, seems to me likely to lead to valuable results. With oblique light, cutting off light from the mirror, the performance of Zeiss' lens is remarkably good.

2. *The Phonograph as a Transmitter.*—By placing Hughes' microphone on the disk of the phonograph the latter will transmit the sounds recorded on the tinfoil to a telephone at a distance. Thus we have a combination of microphone, phonograph and telephone, which promises to be of use. It is very suggestive to hear the phonograph speaking in one room and to know that some one else in another room, or at a long distance off, is also hearing a repetition of the sound. I have no doubt that arrangements might be made by which the sound might be reproduced in a dozen different places at once.

3. *The Working of the Phonograph.*—After a good deal of experience I have come to the conclusion that a thin and slightly elastic membrane is the most suitable for loudness, while a rigid non-elastic membrane is most adapted for distinctness. From a consideration of the histological structure of the drum of the ear this is what one would expect. After the impressions have been made on the tinfoil, distinct speech, in a feeble voice, of most peculiar quality, like what one would imagine to be the tones of the fairies of old, can be heard from one of Marey's tambours, by bringing the point of the lever on the surface of the phonographic cylinder. With this method there is almost no friction, and consequently the marks on the tinfoil are not quickly rubbed out. By connecting a tube with the tambour and carrying it from the tambour to the ear, sounds may be heard, even as speech, after the marks have been so erased from the tinfoil as to be scarcely perceptible to the eye. Thus the tambour, when so used, may be said to be a microphone.

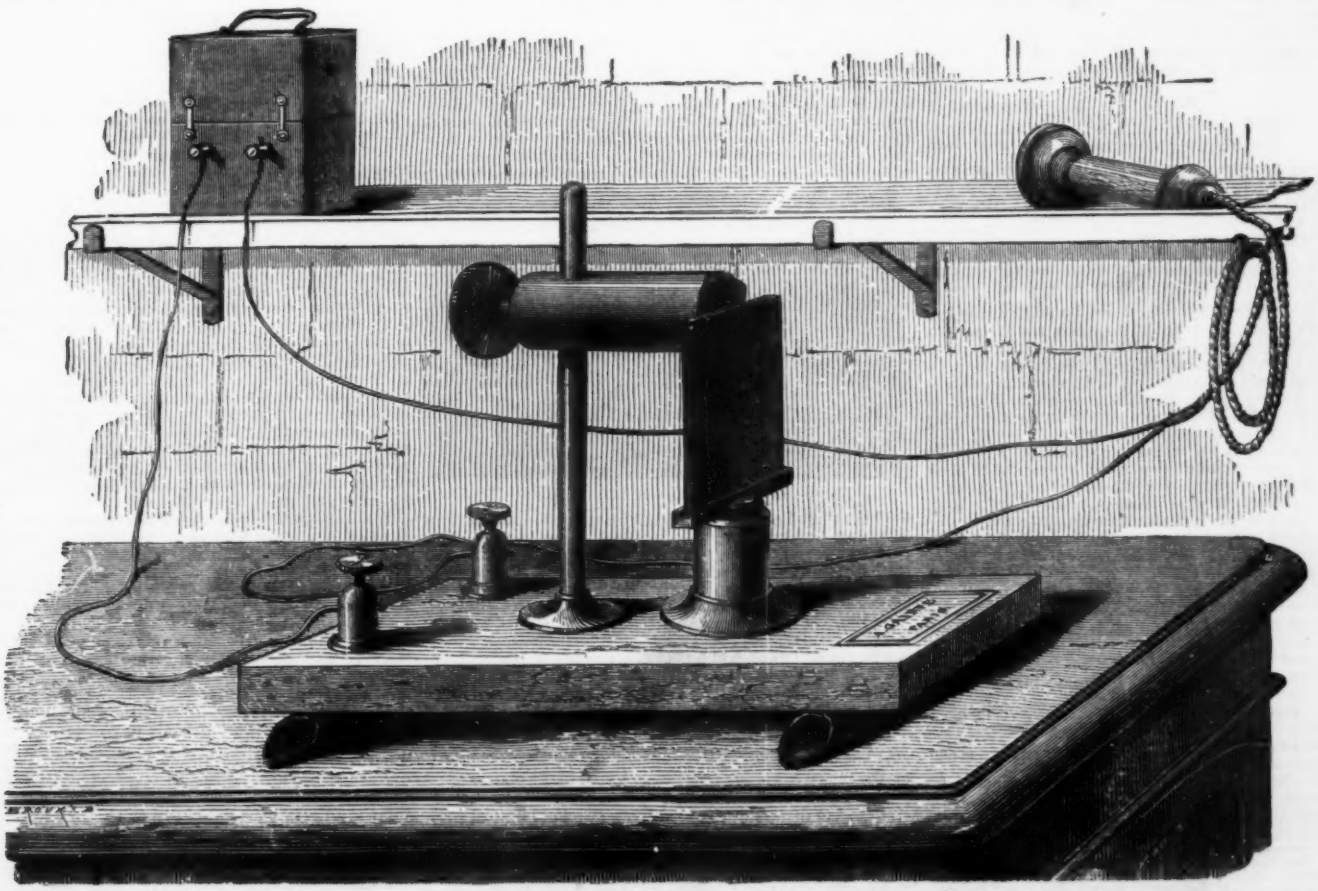
4. *The Microphone.*—I have tried many experiments with the ingenious arrangement of Mr. Hughes, and have been much impressed with its extreme sensitiveness. It may be used to make and break at pleasure the primary coil of the induction machine. When fixed to the box of a monochord the slightest touch of the wire with a camel-hair pencil sounds loudly in the distant telephone. When placed on the sounding-board of a piano, I have heard distinctly a complicated piece of music eighty yards away; when attached to the throat by an India-rubber band, the faintest trill or whisper is audible; and it transmits the muscular sound from a powerful biceps.

5. *A Lecture Experiment.*—Place the heart of a frog on the electrodes of Du Bois-Reymond in connection with a sensitive reflecting galvanometer. The rhythm of the pulsations may then be observed by the swinging to and fro of the spot of light on a transparent screen. This has often been observed by physiologists, but, considered as a lecture experiment, it is very instructive.

6. *The Sensibility of the Telephone to Feeble Currents.*—As an example of this, I may instance the following experiment: The gastrocnemius muscle of a frog was placed on the non-polarizable electrodes of Du Bois-Reymond, so that the transverse section touched the one electrode, and the longitudinal surface the other; the current thus obtained, when sent through a reflecting galvanometer, was sufficient to drive the spot of light from end to end of the scale, placed about three feet in front of the galvanometer; the galvanometer was then disconnected, and a telephone placed in circuit; it was then found that on making and breaking the current, a faint but sharp click of the telephone plate was heard. No click could be heard when the muscle was removed and the two electrodes were connected with a bit of moist blotting paper. The muscle current was therefore sufficient to act on the telephone. The click was stronger when the muscle was placed in contact with two platinum terminals, and when a small carbon microphone was also placed in circuit. I then tried to ascertain whether any effect on the click could be produced by throwing the muscle into a state of tetanus, and I found that in these circumstances no click could be heard at all. In other words, during the state of muscular contraction the muscle current was so diminished (the *negative variation* so called) as to be unable so to affect the telephone so as to produce audible sounds. The telephone thus was used instead of the galvanometer in a physiological experiment.—*Nature*.

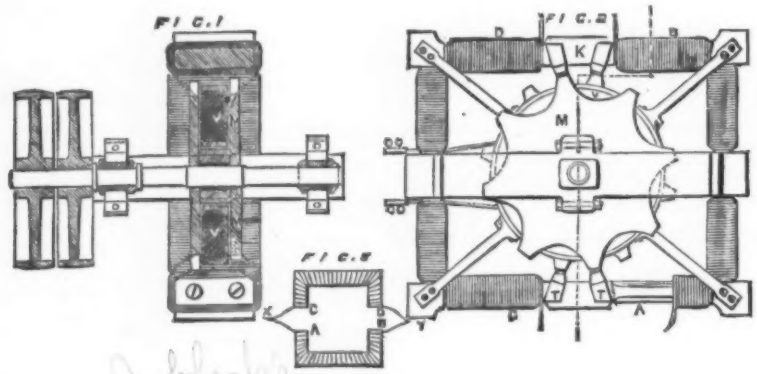
JABLOCHKOFF'S DYNAMO-ELECTRIC MACHINES.

AMONG recent improvements of the dynamo-electric machine, the device by M. Jablochkoff is worthy of notice. In this form, which is illustrated in the engravings, a short bobbin of coiled insulated wire is placed between two soft iron cheeks or disks, which are fixed on a soft iron shaft that passes through the heart of the bobbin, and the shaft and cheeks are caused to revolve, the coil either remaining stationary or revolving with them as required. In order that the principle on which this machine acts may be understood, suppose an electric current is passed through the coil; each of the cheeks will then become magnetic, one pole, north or south, being presented at the circumference of the one and at the center of the other disk, and the opposite pole being presented at the center of the former and at the circumference of the latter. The two disks thus magnetized being united at their centers by the soft iron shaft, the whole would form a magnet having a north or south pole at the circumference of the one disk, and the opposite pole at the circumference of the other. Conversely, when the two cheeks are magnetized so as to have polarity of the kind just mentioned, and when this polarity is alternated, then the central coil has currents of alternate direction induced in it. For thus magnetizing the cheeks the following arrangement is employed: Notches are cut in their peripheries so that they present a series of projections or teeth like those of a toothed wheel, and they are fixed on their common axis so that each tooth of the one directly faces a space between adjoining teeth of the other. They are caused to revolve in front of the poles of stationary magnets or electro-magnets, so arranged that as the cheeks revolve their projecting parts or teeth successively pass opposite poles of these magnets, and thus the alternating polarity required is induced upon them, and corresponding currents are induced in the central



M. GAIFFE'S ARRANGEMENT OF THE EDISON CARBON TELEPHONE.

coil. When electro-magnets are used as the stationary inducing magnets, they are rendered active either by a separate battery or magneto-electric machine producing alternating currents, or by currents from the central coil itself, for which purpose suitable branches are attached to the conductors leading to and from that coil. The machine operating in this manner produces alternating currents, but it may by slight modification be made to produce currents of constant direction, a commutator being for that purpose applied to the central coil or its conductors. When the machine is required to be of considerable power, its dimensions may be increased, or preferably several sets of cheeks may be fixed on one driving shaft with their appropriate bobbins and magnets, the latter arrangement being convenient, as it affords means of producing electricity either of considerable tension or in considerable quantity, as may be desired. In the drawings Fig. 1 represents a longitudinal section taken on the dotted line shown in Fig. 2, which is a front view. A, B, and C, D, are two powerful electro-magnets having cast iron bores. Their poles are separated by pieces, K, K, of brass or copper; T, T, are soft iron armatures; V is the bobbin of coiled insulated wire which is kept stationary; and M, M, are the two notched cheeks or disks, which revolve with the shaft, one on each side of the bobbin. In order to excite the magnets, A, B, and C, D, any known source of electric power may be employed, or a small machine producing alternating currents; or the alternating currents produced from the machine itself, in which case the cores of the electro-magnets are preferably made of iron or steel, or hardened iron. These magnets are, in the first place, excited by a strong current



JABLOCHKOFF'S ELECTRIC MACHINE.

giving the extremities A and D of the same polarity, and B and C the opposite polarity, and being in hard iron or steel they retain the magnetism. On causing the shaft with the cheeks, M, M, to revolve, alternating currents are produced in the coil, V, which, being led through the coils of the magnets, as shown by the diagram, Fig. 3, produce the following results: The current, in flowing from X to Y, divides into the two branches. Half the current would increase the force of the poles, A, B, and the other half would diminish that of C, D. But this diminution is scarcely sensible, the previous magnetic force being retained by induction from the opposite poles, and this magnetism causing resistance in the line, so as to reduce the amount of electrical force passing by it. When the current passes from Y to Z the conditions are inverted. Thus the patentee is enabled to re-enforce both magnets by means of the alternating currents without changing their polarity. The alternating currents produced by the machine above described may be deviated by any known commutator so as to give currents of one direction at each terminal. Also by means of such commutator continuous currents may be transmitted through the coils of the electro-magnets, which in that case should have soft iron cores. The shaft in Fig. 1 is carried in bearings, and is fitted with fast and loose pulleys for driving the apparatus by a steam or gas engine.—*English Mechanic.*

ON A NEW METHOD OF DETECTING OVERSTRAIN IN IRON AND OTHER METALS, AND ON ITS APPLICATION IN THE INVESTIGATION OF THE CAUSES OF ACCIDENTS TO BRIDGES AND OTHER CONSTRUCTIONS.

[A Paper by Robert H. Thurston, C. E., read before the American Society of Civil Engineers, March 20, 1878.]

It has been shown by the writer* and by other investigators that when a metal is subjected to stress exceeding that required to strain it beyond its original apparent, or "primitive," elastic limit, this primitive elastic limit becomes elevated, and that strain diagrams obtained autographically, or by carefully plotting the results of well conducted tests of such metals, are "the *loci* of the successive limits of elasticity of the metal at the successive positions of set."†

It has been shown by the writer also that at the successive positions of set, strain being intermitted, a new elastic limit is, on renewing the application of the distorting force, found to exist at a point which approximately measures the magnitude of the load at the moment of intermission.‡

It has been still further shown by the writer, and by Commander Beardslee, U. S. N., by direct experiment in the Mechanical Laboratory of the Stevens Institute of Technology, and at the Washington Navy Yard, that the normal elastic limit, as exhibited on strain diagrams of tests conducted without intermission of stress, is exalted or depressed when intermission of distortion occurs, according as the metal belongs to the iron or to the tin class.§ This elevation of the normal elastic limit by intermitting strain is, as has been shown, variable in amount with different materials of the iron class, and the rate at which this exaltation progresses is also variable. With the same material and under the same conditions of manufacture and of subsequent treatment, the rate of exaltation is quite definite and may be expressed by a very simple formula. The writer has experimented with bridge material, and Commander Beardslee has examined metal specially adapted for use in chain cables, for which latter purpose an iron is required, as in bridge building, to be tough as well as strong and uniform in structure and composition. The experiments of the latter investigator have extended to a wider range than have those of the writer, and the effect of the intermission of strains considerably exceeding the primitive elastic limit has been determined by him for periods of from one minute to one year.* From a study of the results of such researches and from a comparison with the latter investigation, which was found to be confirmatory of the deduction, the writer has found that, with such iron as is here described, the process of exaltation of the normal elastic limit due to any given degree of strain usually nearly reaches a maximum in the course of a few days of rest after strain, its progress being rapid at first and the rate of increase quickly diminishing with time. For good bridge irons, the amount of the excess of the exalted limit, as shown by subsequent test, above the stress at which the load had been previously removed may be expressed approximately by the formula:

$$E^1 = 5 \log. T + 1{\cdot}50 \text{ per cent};$$

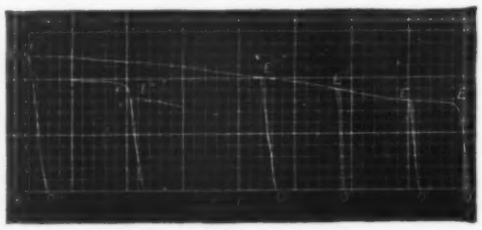
in which the time, T, is given in hours of rest after removal of the tensile stress which produced the noted stretch.

Thus, in the figure, which is a fac-simile of a part of a strain diagram produced by such an iron, during a test in which the intermission of stress was of too brief duration to cause an observable exaltation of the normal elastic limit in a diagram drawn on so small a scale, the point, E, is the primitive elastic limit of the material, and E^I E^{II} E^{III} E^{IV} are the normal elastic limits corresponding to sets under loads which have strained it beyond that primitive elastic limit. In the example here illustrated the primitive limit is found at about 20,000 lbs. per square inch, or 1,400 kilogrammes per square centimeter, and the other points are those corresponding to loads of, respectively, 21,000, 22,500, 25,000, and 30,000 pounds on the inch, or to 1,470, 1,575, 1,750, and 2,100 kilogrammes on the square centimeter. The corresponding extensions, as shown on the diagram, are 1·25, 2·53, 4·50, and 6·78 per cent.

Had the stress been intermitted at either of these points any considerable period of time, there would have been observed a rise in the diagram, as above stated, like that shown in Fig. 1, at E^V, the normal elastic limit, *e*, being, on subsequent test, found altered and a new limit, *e'*, observed. The extent of this elevation of the limit would be the greater as the time of rest was greater, as already seen.

Thus, it is seen that a metal, once overstrained, carries permanently unmistakable evidence of the fact,† and can be made to reveal the amount of such overstrain at any later time with a fair degree of accuracy. This evidence cannot be entirely destroyed, even by a moderate degree of annealing. Often, only annealing from a high heat, or reheating and reworking, can remove it absolutely. Thus, too, a structure, broken down by causes producing overstrain in its tension members, or in its transversely loaded beams (and probably in compression members—although the writer is not yet fully assured of the latter), retains in every piece a register of the maximum load to which that piece has ever been subjected; and the strain sheet of the structure, as strained at the instant of breaking down, can be thus laid down with a fair degree of certainty.

Here, then, when the work above detailed shall have been properly complemented with experimental determinations of



the behavior of all the materials of general use in construction, may be found a means of tracing the overstrains which have resulted in the destruction or the injury of any iron or steel structure, and of ascertaining the cause and the method of its failure, in cases frequently happening in which they are indeterminable by any of the usual methods of investigation.

The fact of the normal variation of the elastic limit, as change of form progresses under gradually increased load, has been well established by the experiments of Hodgkinson, Clark, Mallett, and other English investigators; by Tresca, particularl France; nyi, by Werder and Bauschinger in Germany, and by Beardslee, the writer, and others in the United States.

The exaltation of the series of normal limits so produced, still further, as shown by the writer and as seen in Fig. 1, by the intermission of strain, as at E^V, is also a matter of no uncertainty as to its character, although much more study is needed to determine the modifying effects of time of intermission on metals of the two great classes and of differing composition. The method above outlined of determining the extent of previous overstrain may therefore be expected to have many useful applications.

In illustration of an application of the facts thus reviewed to the determination of the causes and the method of the injury or the destruction of a structure, assume the existence of a set of conditions which is familiar to probably every engineer in the country who has seen much of the Howe truss, and of some other forms of bridges, as frequently built before the present generation of professional bridge builders effected a revolution in that department of engineering construction.

Suppose one of these bridges to have been built with a span of 150 feet, and to have been given such proportions that, with a weight of 1,200 pounds per running foot and a load of one ton per running foot, the maximum stress on end rods, or other members most strained, is as high as 20,000 pounds per square inch of section of metal. Suppose this bridge to have its tension members composed of a fair, but unrefined, iron, having an elastic limit at about 17,000 pounds per inch, and a tenacity of 45,000 to 48,000 pounds, and with an extensibility of about 20 per cent.

Suppose this structure to break down under a load exceeding that usually sustained in ordinary work, and the cause of the disaster to be "involved in mystery."

Suppose portions of the several tension members to be subsequently removed, and, a few days after the accident, to be carefully tested, with the following results:

	Elastic limit.	Tenacity.
Sample No. 1	16,500	46,000
" " 2	18,000	48,000
" " 3	30,000	48,000
" " 4	22,500	50,000
" " 5	25,000	52,000
" " 6	27,500	52,000
" " 7	28,000	52,000
" " 8	30,000	52,000
" " 9	32,000	53,000
" " 10	34,000	53,000

And that the extensibility is found to be as little as from ten to fifteen per cent.

Suppose it to be found that the tension members were straight bolts without upset ends, the threads being cut, as was once common, in such a manner that the section at the bottom of the thread is one third less than the sectional area of the body of the bar. Suppose, finally, that the location of the tested pieces in the structure being noted, it is found that the stronger metal, having also the highest elastic limit, came from the neighborhood of the point at which the bridge gave way, and that the weakest metal and that exhibiting the lowest elastic limit came usually from points more or less remote from the break. It is not likely that in all cases the increase in the altitude of the elastic limit and the increase noted in the ultimate strength of the samples would exhibit a regular order coincident with the order of the rods as to position in the structure; since the magnitude and the arrangement of the bars would, to a certain extent, determine the relative amounts of strain thrown upon them by overloading any one part of the truss. For present purposes we may assume the order of arrangement to be thus coincident.

On examination of the figures as above given, the engineer would conclude: First, that the original apparent elastic limit of the iron used in this case must have been not far from 17,000 pounds per square inch, and that its tenacity was between 46,000 and 48,000 pounds; secondly, that this primitive elastic limit had been elevated, by subsequent loads exceeding that amount, to the higher figures given by the bars numbered from 3 to 10 inclusive; thirdly, that the ultimate strength of the material had been, in some examples given above, increased by similarly intermitted strain.

It would be concluded that the ordinary loads, such as had been carried previously to the entrance upon the bridge of that which caused its destruction, never exceeded, in their straining action, 16,500 pounds per square inch of section of tension rod at the part of the truss from which No. 1 had been taken, and that the other rods tested had carried probably at the time of the accident loads approximately equal to those required to strain them to the extent measured by their elastic limits at the time of testing them.

It would be concluded that the rod from which No. 10 was cut was either that most strained by the load, and therefore nearest the point of fracture of the truss, or that it was very near that point, and it would be made the basis of comparison in further studying the case.

As this elastic limit approaches most nearly the breaking strength of the metal, we may apply the formula for the elevation of the elastic limit with time after intermitted strain which has been above given as derived from tests of a metal of very similar quality. Taking the time of intermission as one week, the extent of the increase has a probable value not far from $E^1 = 5 \log. 168 + 1{\cdot}5 =$ nearly $12\frac{1}{2}$ per cent. The magnitude of the stress upon this piece at the time of the accident was therefore 34,000 less one ninth of that value, or about 30,000 pounds per square inch of cross section of the bar. This corresponds to about 45,000 pounds per square inch at the bottom of the thread, and is within five per cent of the primitive breaking strength of the iron. The bar, if broken at the screwed portion, has therefore yielded either under a dead load which was at least equal to its maximum resistance, or under a smaller load acting so suddenly as to have the effect of a real "live load." Or the slight difference here noted may be due to a flaw at the point of fracture. However that may be, it is almost certain that the body of the rod has sustained a stress of not far from 30,000 pounds per square inch.

But it is found, on further investigation, that the load on the structure at the time of the accident was but sufficient to make the maximum stress on these rods—if properly distributed—20,000 pounds per square inch at the threaded part of the piece; which piece, it has been seen, has been broken by a strain nearly double that figure. The fact is at once inferable that the load came upon these members with such suddenness as to have at least the effect of a live load (as taken in the text books), and giving a maximum stress equal to twice that produced by the same load gradually applied, *i. e.*, the case in which the load falls, through a height equal to the extension of the piece strained by it, the resistances being assumed to increase directly as the extension up to the point of rupture—an assumption which is approximately correct for brittle materials like hard cast iron, but quite erroneous in the case of some ductile materials, which latter sometimes give a "work of ultimate resistance" amounting to three fourths or even five sixths of the product of maximum resistance by the extension.

This accident was therefore caused by the entrance upon the bridge of a load capable of straining the metal to about one half of its ultimate strength, if slowly applied, but which, in consequence of its sudden application, doubled that stress.

This sudden action may have been a consequence either of

* See Trans. Am. Soc. C. E., 1874, *et seq.*; *Journal Franklin Institute*, 1874; Van Nostrand's *Eclectic Engineering Magazine*, 1874, etc., etc.

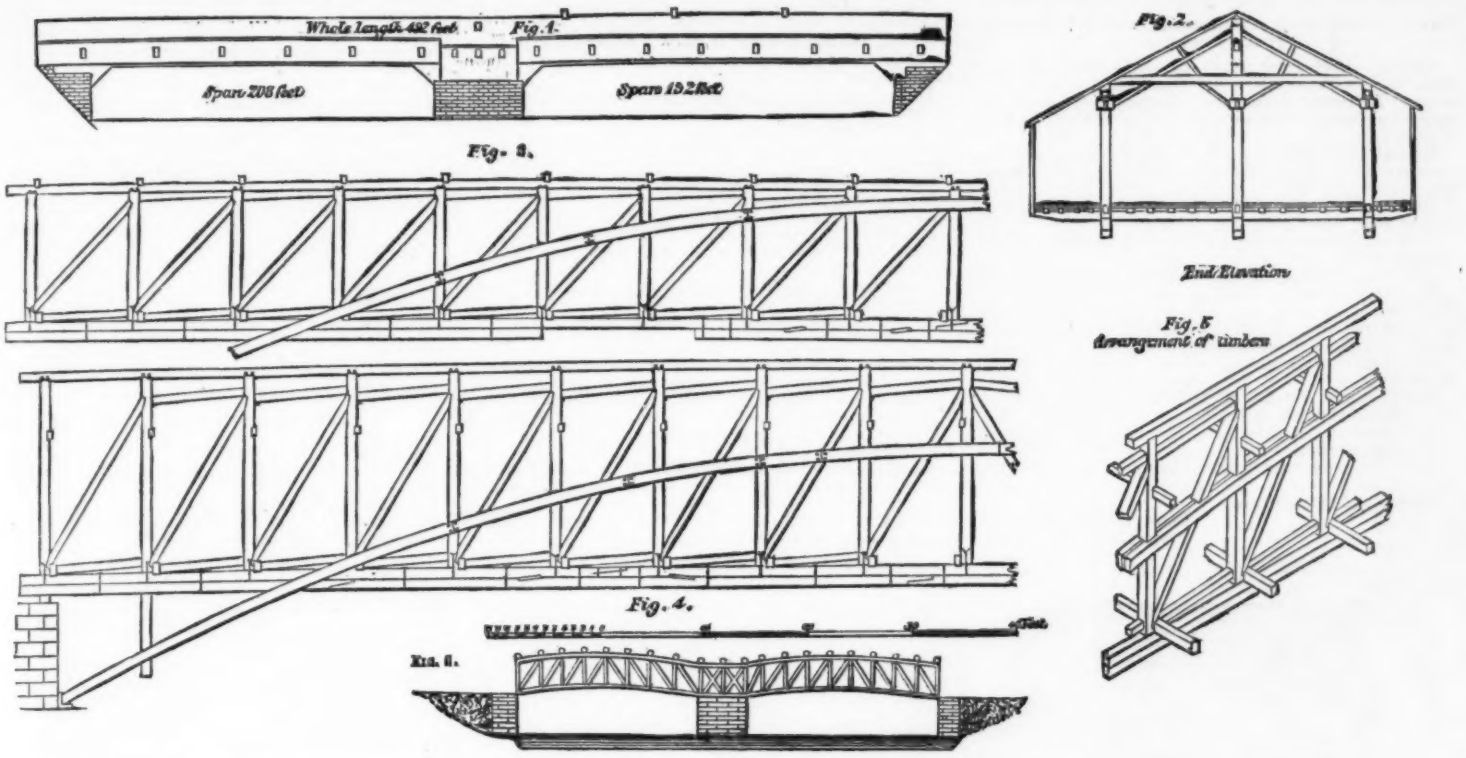
† "On the Strength, etc., of Materials of Construction," 1874, Sec. 20.

‡ "On the Mechanical Treatment of Metals," *Metallurgical Review*, 1877; *Engineering and Mining Journal*, 1877.

§ Trans. Am. Soc. C. E., 1877.

* The result of this investigation is completed, and will be presented to the President of the United States by the United States Board appointed to test iron, steel, etc.

† The writer has found by subsequent tests that transverse strain produces the same effect upon the elastic limit for tension.



A FIFTY-YEAR OLD TIMBER BRIDGE OVER THE KENNEBEC RIVER, AT AUGUSTA, MAINE.

its coming upon the structure at a very high speed, or a result of the loosening of a nut, or of the breaking of a part of either the bridge floor or of one of the trucks of the train. The latter occurrence, permitting the load to fall even a very small distance, would be sufficient.

This paper is not presented as a perfectly satisfactory statement of definite facts from which absolutely reliable conclusions can be drawn. The whole subject is deserving, however, of very careful and very extended experimental investigation, and the writer has been able to obtain but a small amount of satisfactory definite information in regard to it as yet. The figures given do not exactly represent those obtained from any actual case. They do, however, fairly illustrate the limited experience of the writer, and are nearly exact for at least one case; they may serve to indicate the possible value of the cautious application of the method here outlined of studying the causes of such accidents as are considered in the hypothetical case here taken.

The same method may sometimes be used to ascertain the probable cause of a boiler explosion by determining whether the metal has been subjected to overstrain in consequence of overpressure. The causes of accidents to machinery may also be thus detected, and many other applications will suggest themselves to every engineer.

A FIFTY-YEAR OLD WOODEN BRIDGE.

THE first company for building a bridge across the Kennebec river at Augusta was incorporated February 8, 1796. The bridge was commenced May 5, 1797, and finished upon November 21st of the same year. It cost $27,000, and was of the general form shown by the annexed sketch, Fig. 6. This bridge was built of white pine, some of the timbers being no less than 70 ft. in length and 16 ins. square.

The pier above low water was of stone placed on a wooden foundation 40 ft. square, made of large timbers locked together and braced from side to side, filled with ballast and floored with heavy timbers, on which stone walls 9 ft. thick were placed, forming on the inside an oval opening. The ice breaker was at first of wood strapped with iron. This was afterward replaced with stone. This bridge, when built, was the only one across the Kennebec, and was the greatest enterprise of the kind in the district of Maine.

Upon Sunday, June 23, 1816, the eastern span, which had become much decayed, having been exposed to the weather for nearly twenty years, fell down. Upon the 18th of March, 1818, the western span, which still remained, was removed and a new bridge substantially like the present one was erected, being completed late in August of the same year. This bridge was burnt April 2, 1827, and was at once rebuilt, the present structure, of which we annex engravings, being opened upon the 18th of the following August, 138 days from the burning of the old bridge, and 74 days from the time when most of the timber was standing in the woods. On February 20, 1870, a freshet occurred in the Kennebec, an ice jam forming below the town and backing up the water until it reached within 4 ft. of the lower stringers of the bridge, submerging the lower ends of the arches. The floating ice, which was so piled up as to be from 12 ft. to 15 ft. in thickness, cut off two or three arches beneath the bridge at the shore end of the eastern span, all three arches at the west end of the same span, and two of the three arches at the east end of the western span. While the bridge was in this critical condition, being supported entirely by the truss alone, the railroad bridge above was carried away and came down endwise in one piece, 175 ft. long, struck near the eastern end of the covered bridge, tearing away the studding and boarding, settled down until it forced its head under the bridge, moved slowly forward and sideways till it reached the middle of the eastern span, where it hung for a moment rising and falling, and finally came out below the bridge near the pier, having cut off a large part of the lower stringer of the up stream and middle trusses of the eastern span. The bridge was then closed for eleven days for repairs, when it was again opened for travel and has since remained in good condition, being now fifty-one years old. The workmanship of the structure was very thorough and the material the best white pine. The arches are in two pieces with a packing strip between, as shown in the drawings, being heaved to the required curve. As an example of an old timber bridge of large span the structure possesses more than ordinary interest.—*Engineering.*

THE PARIS EXHIBITION—JURORS REPRESENTING THE UNITED STATES.

FIRST GROUP.—WORKS OF ART.

Class 1—*Oil Paintings.*—Paintings on canvas, on panel, and on other grounds.

Class 2—*Various Paintings and Drawings.*—Miniatures, water-color paintings, pastels, and drawings of every kind; paintings on enamel, earthenware, and porcelain; cartoons for stained glass windows and frescoes.

FRANK D. MILLET.

Class 5—*Engravings and Lithographs.*—Engravings, colored engravings. Lithographs executed with pencil and with brush, chromo-lithographs. THOMAS P. RICH, JR.

SECOND GROUP.—EDUCATION AND INSTRUCTION, APPARATUS AND PROCESSES OF THE LIBERAL ARTS.

Class 7—*Organization and Appliances for Secondary Instruction.*—Plans and models of establishments for secondary instruction, lyceums, grammar schools, colleges, industrial and commercial schools. Arrangement and furniture of such establishments.

Collections: Classical works, maps, and globes.

Appliances for technological and scientific instruction, and for teaching the fine arts, drawing, music, and singing.

Apparatus and methods for instruction in gymnastics, fencing, and military exercises. JOHN D. PHILBRICK.

Class 9—*Printing, Books.*—Specimens of typography; autographic proofs; lithographic proofs, blank or colored; proofs of engravings.

New books and new editions of books already known; collections of works forming special libraries; periodical publications. Drawings, atlases, and albums.

HENRY STEVENS.

Class 10—*Stationery, Bookbinding, Painting and Drawing Materials*—Paper; card and pasteboard; inks; chalks; pencils; pastels; all things necessary for writing-desks and offices; inkstands; apparatus for weighing letters, etc.; copying presses.

Objects made of paper: Lamp shades, lanterns, flower-pot covers.

Registers, copy-books, albums, and memorandum books; bindings, loose covers for books, cases, etc.

Various products used in water-color painting and tinting; colors in cakes, pastels, bladders, tubes, and shells. Instruments and apparatus for the use of painters, draughtsmen, engravers, and modelers. JOHN RUSSELL YOUNG.

Class 12—*Photographic Proofs and Apparatus.*—Photographs on paper, glass, wood, stuffs, and enamel. Heliographic engravings, lithographic proofs. Photo-lithographic proofs, photographic stereotypes, stereoscopic proofs, and stereoscopes. Enlarged photographs. Color photographs.

Instruments, apparatus, and chemicals necessary for photography. Materials and appliances used in photographic studios. HENRY C. WHITE.

Class 13—*Musical Instruments.*—Non-metallic wind instruments: With common mouth-pieces, with reeds with or without air reservoirs.

Metallic wind instruments, simple, with lengthening pieces, with slides, with piston, with keys, with reeds.

Wind instruments with keyboards: Organs, accordions, etc.

Stringed instruments played with the fingers or with the bow, without keyboards.

Stringed instruments with keyboards: Pianos, etc.

Instruments played by percussion or friction.

Automaton instruments, barrel organs, bird organs.

Separate parts of musical instruments and orchestral appliances. B. BEREND, JR.

Class 14—*Medicine, Hygiene, and Public Relief.*—Appliances, instruments, and apparatus requisite for anatomical and histological works.

Plastic anatomical models.

Instruments of medical research.

Apparatus and instruments for dressing wounds and for simple surgery, general and local; anæsthetic apparatus.

Surgical instruments grouped according to their purposes: Instruments for amputations, resection. Special instruments: Obstetrics, ovariotomy, urinary channels, ophthalmology, dentistry, etc.; electro-therapeutic apparatus.

Apparatus for plastic and mechanical prosthesis, orthopædic apparatus.

Trusses.

Apparatus for restoring persons apparently drowned or suffocated.

Baths and hydro-therapeutic apparatus: Gymnastical apparatus for medical and hygienic purposes.

Plans and models of hospitals, various asylums, houses of refuge, poor-houses, lunatic asylums. Arrangement and furniture of such establishments. Various apparatus for infirm persons, invalids, and lunatics. Accessory objects for the medical, surgical, and pharmaceutical services in hospitals or infirmaries.

Chests and cases of instruments and medicines for military and naval surgeons. Means and apparatus for succoring the wounded on battle-fields. Civil and military ambulances.

Appliances, instruments, apparatus, and all things requisite for veterinary surgery. DR. THOMAS W. EVANS.

THIRD GROUP.—FURNITURE AND ACCESSORIES.

Class 17—*Cheap and Fancy Furniture.*—Sideboards, bookcases, tables, dressing-tables, beds, sofas, couches, billiard tables, etc. THOMAS B. OAKLEY.

Class 24—*Goldsmiths' and Silversmiths' Work.*—Church plate, ornamental plate, and table plate, gold and silver toilet articles, writing materials, etc. Electrotypes.

JACQUES SCHEIB.

Class 26—*Clocks and Watches.*—Separate parts of clocks of large or small size.

Watches, chronometers, pedometers; various time-keepers, etc. Time-pieces and clocks working by springs or weights, regulators, metronomes.

Astronomical clocks; marine chronometers, traveling clocks. Alarums, etc. Water clocks and sand glasses. Electric clocks. Turret and church clocks.

THOS. W. KNOX.

Class 27—*Apparatus and Processes for Heating and Lighting.*—Fire-grates, fire-places, stoves, and hot-air stoves. Accessory objects for heating. Kitchen ranges and apparatus for heating and cooking by gas.

Apparatus for heating by the circulation of hot water, steam, or heated air. Ventilating apparatus. Drying apparatus; drying stoves.

Enamelers' lamps, blow-pipes, portable forges.

Lamps for illuminating purposes, fed with various oils.

Accessory objects for lighting. Matches.

Apparatus and accessory objects for lighting by gas.

Lamps for the electric light. Apparatus for the use of the magnesium light, etc. JAMES W. TUCKER.

FOURTH GROUP.—TEXTILE FABRICS, CLOTHING, AND ACCESSORIES.

Class 38—*Clothing for Both Sexes.*—Men's clothes; women's clothes. Water-proof clothing.

Men and women's head-dresses; artificial flowers and feathers.

Wigs and works in hair.

Boots and shoes.

Children's clothes.

Clothing peculiar to various professions and trades.

Native costumes of different countries.

ANTHONY VAN BERGER.

Class 40—*Portable Weapons and Hunting and Shooting Equipments.*—Defensive armor; cuirasses and helmets.

Blunt weapons: Maces, life-preservers.

Side-arms: Foils, swords, sabers, bayonets, lances, axes, hunting-knives.

Missile weapons: Bows, cross-bows, slings.

Fire-arms: Guns, rifles, pistols, and revolvers.

Accessory objects appertaining to every kind of small arms; powder-flasks, bullet-moulds, etc.

Round, oblong, hollow, and explosive projectiles. Percussion caps, priming, cartridges.

Hunting and sporting equipments. CARROLL TEVIS.

FIFTH GROUP.—MINING INDUSTRIES, RAW AND MANUFACTURED PRODUCTS.

Class 43—*Mining and Metallurgy.*—Collections and specimens of rocks, minerals, ores. Ornamental stones. Hard stones. Refractory substances. Earths and clays. Various mineral products. Raw sulphur. Rock salt; salt from salt springs.

Mineral fuel: Various kinds of coal, coal-dust, and compressed coal. Asphalt and rock asphalt. Bitumen. Mineral tar. Petroleum, etc.

Metals in a crude state: Pig-iron, iron, steel, cast-steel, copper, lead, silver, zinc, etc. Alloys.

Products of washing and refining precious metals, of gold-beating, etc.

Electro-metallurgy: Objects gilt, silvered, or coated with copper, steel, nickel, etc., by the galvanic process.

Products of the working of metals: Rough casting, bells, wrought iron, iron for special purposes, sheet iron and tin plates, iron plates for casing ships and constructions, etc.

Sheet iron coated with zinc or lead; copper, lead and zinc sheets, etc.

Manufactured metals: Blacksmiths' work, wheels and tires, unwelded pipes, chains, etc.

Wire-drawing. Needles, pins, wire ropes; wire work and wire gauze, perforated sheet iron.

Hardware, edge-tools, ironmongery, copper, sheet iron, tinware, etc.

Other metal manufactures.

PROF. WM. P. BLAKE,
PROF. HENRY B. NASON.

SIXTH GROUP.—APPARATUS AND PROCESSES USED IN THE MECHANICAL INDUSTRIES.

Class 51—*Agricultural Implements and Processes used in the Cultivation of Fields and Forests.*—Plans of culture, distribution, and management of crops. Apparatus and works for agricultural engineering, draining, irrigation, etc. Plans and models of farm buildings.

Tools, implements, machines, and apparatus used in husbandry, sowing and planting, harvesting, preparation and preservation of crops.

Various agricultural machines worked by horse-power or by steam.

Carts and other rural means of transport.

Locomotives and horse-gins.

Manures, organic or mineral.

Apparatus for the physical and chemical study of soils.

Plans of different systems of replanting, managing, and cultivating forests.

Apparatus used in the cultivation of forests, and the trades appertaining thereto.

Apparatus used in the manufacture of tobacco.

FRANK C. JOHNSON.

Class 54—*Machines and Apparatus in General.*—Separate pieces of machinery; bearing, rollers, slide bars, eccentrics, toothed wheels, connecting rods, cranks, parallel joints, belts, funicular apparatus, etc. Gearing, spring and catch work, etc. Regulators and governors.

Lubricators.

Machines for counting and registering. Dynamometers, steam-gauges, weighing machines. Gauges for liquids and gas.

Machines used for moving heavy weights.

Hydraulic machines for raising water, etc.; norias (chain pumps), scoop wheels, hydraulic rams, etc.

Class 59—*Apparatus and Processes used in the Manufacture of Furniture and Objects for Dwellings.*—Machines for cutting veneers. Turning webs, saw-frames, etc.

Machines for cutting the mouldings and beadings of frames, the squares of inlaid floors, furniture, etc. Lathes and other apparatus used in carpentering and cabinet-making.

Machines for stamping and burnishing. Machines and apparatus for working stucco, papier-mâché, ivory, bone, and horn.

Machines for pointing, carving, and reducing statues; for engraving, engine-turning, etc.

Machines for making bricks and tiles; machines for making artificial stones.

Machines for sawing and polishing hard stones, marbles, etc.

ROBERT GRIMSHAW.

Class 62—*Carriages and Wheelwrights' Work.*—Separate parts of wheels and carriages: Wheels, tires, axles, axle-boxes, iron work, etc. Spring and various methods of hanging carriages.

Different systems of harnessing. Brakes.

Wheelwrights' work: Wagons, tumbrels, drays, and other vehicles for special purposes.

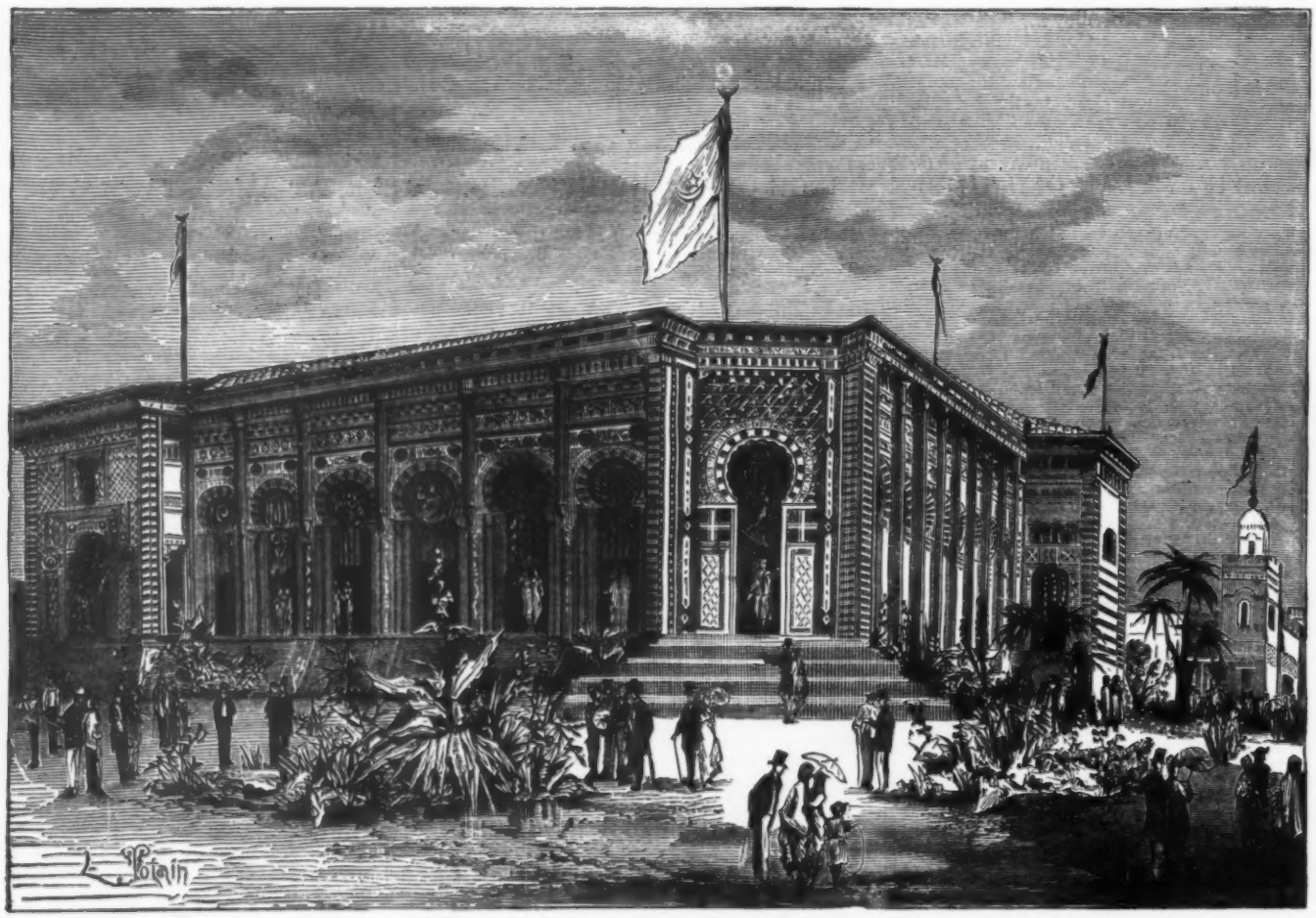
Carriages: Public, state, and private carriages; sedan chairs, litters, sledges, etc.; velocipedes. JOHN MUNROE.

Class 64—*Railway Apparatus.*—Separate parts: Springs, buffers, brakes.

Permanent way: Rails, chairs, crossings, switches, fish-plates, turn-tables, buffers, feeding cranes, and tanks; optical and acoustic signals.

Permanent way for tramways.

Rolling stock: Wagons for passengers, for carrying earth, goods, cattle; locomotives, tenders.



PAVILION OF THE BEY OF TUNIS, AT THE PARIS EXHIBITION.

Class 46—*Agricultural Products not used for Food.*—Textile materials: Raw cotton, flax, and hemp, scutched and dun-scutched; textile vegetable fibers of all kinds; wool, washed or unwashed; cocoons of the silk worm.

Various agricultural products used in manufactures, in pharmacy, and for household purposes; oleaginous plants; oil, wax, resin.

Tobacco in leaves or manufactured. German tinder. Tanning and dyeing substances.

Preserved fodder, and substances specially intended for feeding cattle. ASHBEL SMITH.

Class 47—*Chemical and Pharmaceutical Products.*—Acids, alkalies, salts of all kinds. Sea-salt and products extracted from mother-water.

Various products of chemistry: Wax and fatty substances; soaps and candles, raw materials used in perfumery; resins, tar, and the products derived from them; essences and varnishes; various coating substances; blacking. Objects made of India-rubber and gutta-percha; dyes and colors.

Mineral waters and natural and artificial aerated waters. Raw materials used in pharmacy. Medicines, simple and made up. PROF. WM. H. CHANDLER.

Class 49—*Leather and Skins.*—Raw materials used in the dressing of skins and leather.

Raw hides, salted hides. Tanned, curried, dressed, or dyed leather. Varnished leather.

Morocco and sheep skins; skins grained, shamoyed, tawed, dressed, or dyed. Prepared skins for glove-making. Skins and furs, dressed and dyed. Parchment.

Gut-work: Strings for musical instruments, gold-beaters' skin, sinews. ADOLPH H. REITLINGER.

Hydraulic engines, water-wheels, turbines, hydraulic lifts.

Accumulators and hydraulic presses.

Steam engines. Boilers, steam generators, and apparatus appertaining thereto.

Apparatus for condensing steam.

Machines set in motion by the evaporation of ether, chloroform, ammonia, or by a combination of gases.

Machines set in motion by gas, hot air, and compressed air.

Electro-magnetic machines. Windmills and panemones. Air-balloons. PROF. GEORGE DAVIDSON.
THOMAS JAMES SLOAN.

Class 55—*Machine Tools.*—Engines and tools for preparing wood for the workshop. Machines for making casks.

Machines for cutting cork. Lathes, boring and planing machines. Slotting, drilling, and shaping machines. Screw-cutting engines and riveting machines. Various kinds of tools used in machine workshops.

Tools, engines, and apparatus for pressing, crushing, working up, sawing, polishing, etc. Special tools and engines used in various trades. B. B. HOTCHKISS.
CHARLES R. GOODWIN.

Class 58—*Apparatus and Processes for Sewing and Making up Clothing.*—Ordinary implements used by tailors and seamstresses. Sewing, quilting, hemming, and embroidering machines.

Implements for cutting out materials and leather for making garments and shoes.

Machines for making, nailing, and screwing boots and shoes.

Machines for the application of India-rubber.

DAVID G. LITTLEFIELD.

Self-moving carriages; locomotives for roads.

Special tools and machines for the maintenance, repair, and construction of railways.

Apparatus for inclined planes and self-acting planes; apparatus and engines for atmospheric railways; models of engines, of systems of traction, of apparatus appertaining to railways.

Models, plans, and drawings of platforms, stations, and engine houses, and other buildings necessary for the working of railways. ROBERT M. DELAPLAINE.

Class 66—*Apparatus and Processes of Civil Engineering, Public Works and Architecture.*—Building materials: Stone, wood, metals; ornamental stones; lime, mortar, cements, artificial stone, and concrete; roofing tiles, bricks, paving tiles; slates, pasteboard, and felt for roofing.

Apparatus and products of processes used in the preservation of wood. Apparatus and instruments for testing building materials.

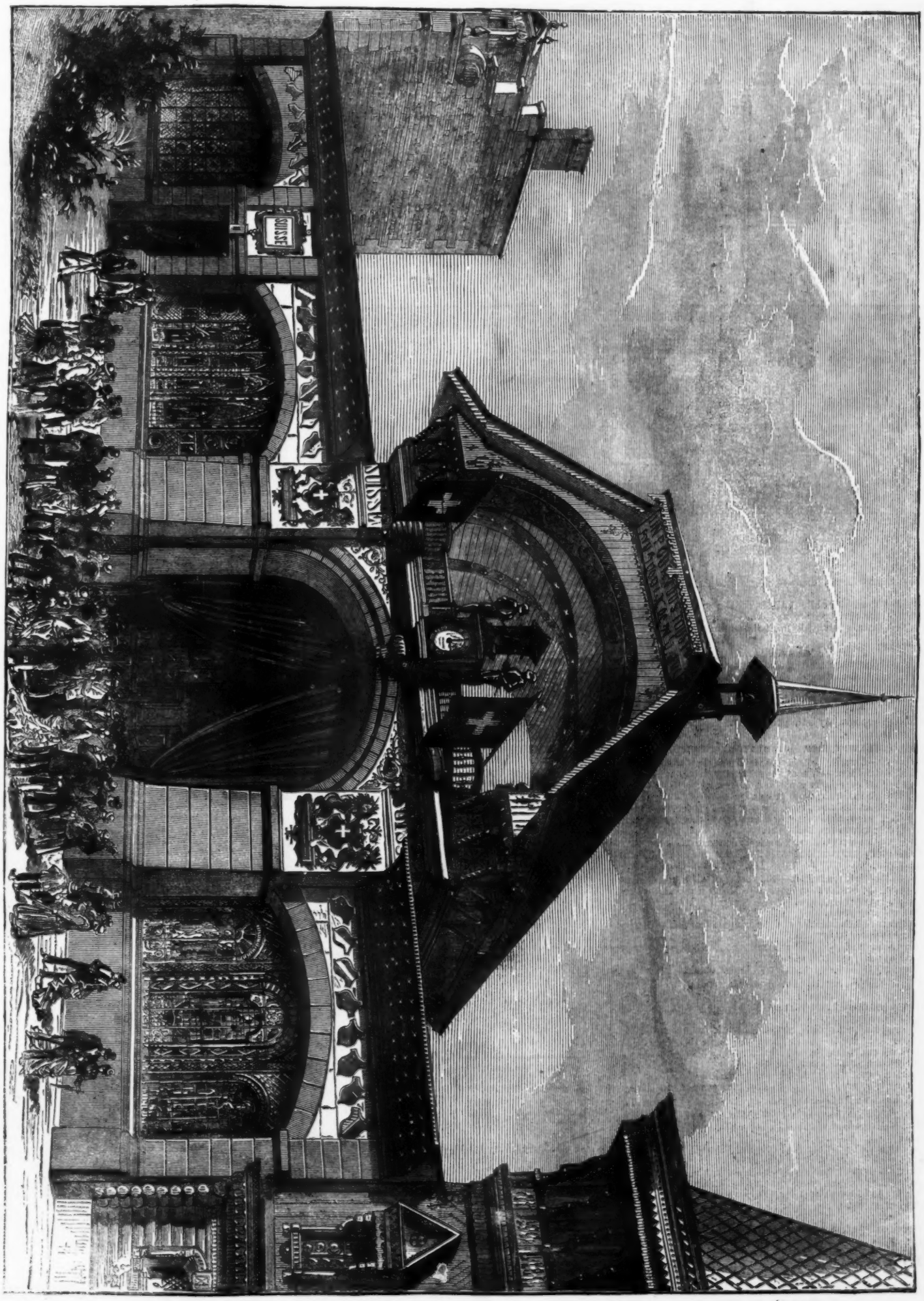
Apparatus for earth-works, excavators. Apparatus used in building yards. Tools and processes used by stone-dressers and cutters, masons, carpenters, tilers, blacksmiths, joiners, glaziers, plumbers, house-painters, etc.

Locksmiths' work: Locks, padlocks, railings, balconies, banisters, etc.

Apparatus and engines used in making foundations: Pile-drivers, and pile-work, screw-piles, pumps, pneumatic apparatus, dredging-machines, etc. Apparatus used in hydraulic works connected with harbors, canals, rivers.

Apparatus used in the supply of water and gas. Apparatus used in the maintenance of roads, plantations, and public walks.

Models, plans, and drawings of public works: Bridges,



ENTRANCE TO THE SWISS SECTION.—PARIS EXHIBITION.

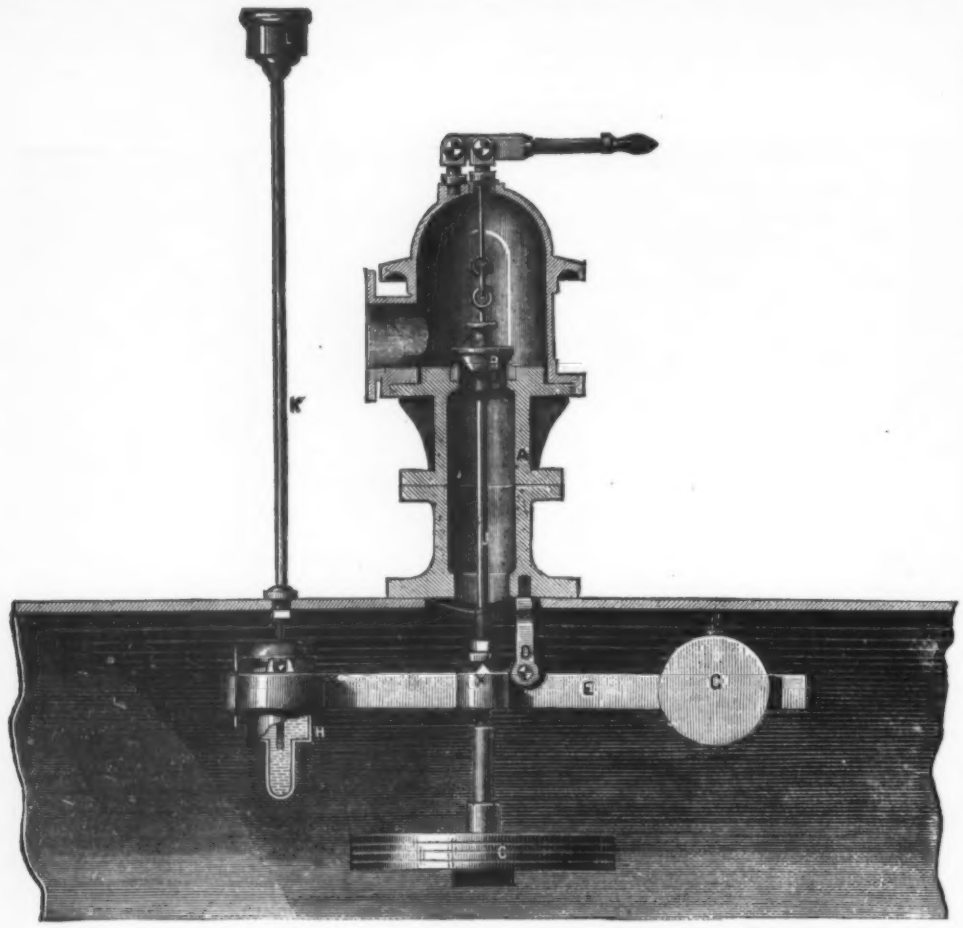


FIG. 1.—VALVE FOR OVERPRESSURE.

viaducts, aqueducts, drains, canal bridges, dams, weirs, etc.

Light-houses. Public buildings for special purposes; buildings for civil purposes; mansions and houses for letting; workmen's towns, industrial dwellings, etc.

PROF. WILLIAM WATSON.

Class 68—Materials and Apparatus for Military Purposes.—Military engineering and fortifications.

Artillery, gun-carriages, and weapons and projectiles of every kind.

Military equipment, clothing, and encampments.

Military transport service.

Military topography and geography.

W. W. H. DAVIS.

SEVENTH GROUP.—ALIMENTARY PRODUCTS.

Class 69—Cereals, Farinaceous Products, and Products Derived from them.—Wheat, rye, barley, rice, maize, millet, and other cereals in grain and in flour.

Grain without husk, and groats.

Fecula from potatoes, rice, lentils, etc., gluten.

Tapioca, sago, arrow-root, cassava, and other fecula, compound farinaceous products, etc.

Italian pastes, semolina, vermicelli, macaroni.

Alimentary preparations as substitutes for bread, home-made paste, etc.

DR. WILLIAM JOHNSTON.

Class 72—Meat and Fish.—Salt meat of all kinds. Meats preserved by various processes. Meat and soup cakes. Hams and prepared meats.

Poultry and game.

Salt fish, fish in barrels; cod, herrings, etc.; fish preserved in oil; sardines, tunny, etc.

Crustacea and shell-fish: Lobsters, shrimps, oysters, potted oysters, anchovies, etc.

DR. EDWARD PEPPER.

Class 75—Fermented Drinks.—Vin ordinaire, red and white.

Sweet wines and still wines.

Sparkling wines.

Cider, perry, and other beverages made from cereals.

Fermented drinks made from vegetable sap, from milk, and sweet substances of all kinds.

Brandies and alcohols.

Spirits: Gin, rum, tafia, kirsch, etc.

DR. ANTOINE RUPPANER.

EIGHTH GROUP.—AGRICULTURE AND PISCICULTURE.

Class 76—Specimens of Farm Buildings and Agricultural Works.—Examples of the farm buildings of various countries.

Examples of stables, cattle-sheds, sheep-folds, pig-sties, and of premises for rearing and fattening such animals.

Utensils used in stables, cattle-sheds, kennels, etc.

Apparatus for preparing the food of animals.

Agricultural machinery in motion: Steam plows, reaping and mowing machines, hay-making machines, thrashing machines, etc.

Specimens of agricultural works: Distilleries, sugar-mills, sugar refineries, breweries, works for the preparation of flour, fecula, starch; silk-worm nurseries, etc.

Presses for wine, cider, oil.

DR. EDWARD H. KNIGHT.

LABOR IN FRANCE.

GENERAL TORBERT, Consul General at Paris, sends to the Department of State a voluminous report of the trade of France. In the Department of the Seine, the average daily wages of laborers is 90 cents; number of working days in a year, 275. During the harvest season soldiers of the army work in the fields, earning 34 cents a day. The typical French family of seven persons earns in a year about $179.20, and expends about $167.20. The advance in wages and cost of living during the last five years estimated at 15 to 20 per cent. Wages of artisans and mechanics daily (maximum): Jewelers, $2.20; butchers, $1.40; bakers, $2; bricklayers, $1; coach-makers, $1.40; hatters, $1.80; carpenters, $1.30; shoemakers, $1.20; cabinet makers, $1.10; printers, $1.30; milliners, per month, $30; pastry cooks, the same; tailors, $1.60; weavers, 80 cents. The difference of wages between men and women was, in 1871, 49 per cent. in favor of the former. In 1875 the difference was but 28 per cent. A day's work is ten hours, summer and winter. Workmen paid by the hour are rated at one-tenth of the price per day. The average price of beef is 13·6 cents a pound; veal, 18·6; mutton, 15·2; pork, 17·2. The domestic servant in France receives a much larger income than the best of skilled female laborers, from the percentage derived from all the purchases made for the family. This tax is an established custom.

STEAM AND CHECK VALVES AT THE PARIS EXHIBITION.

IT is a common practice, and an almost necessary arrangement, when several boilers are laid down side by side, to have their steam pipes united into one main pipe, which conducts the whole body of steam to the engine, etc.; and in order to be able to lay off any one of the boilers for repairs, cleaning, etc., it has been usual to provide separate steam valves for that purpose—one to each boiler. This arrangement is quite efficient as long as the necessary care is bestowed in keeping these valves opened or closed, as may be wanted, according to requirements; but in consequence of several cases having occurred of inspectors or boiler attendants having been seriously injured, through the steam valve being opened by mistake, while examining the inside of boilers, Messrs. Hopkinson, in considering the best means of avoiding similar accidents in future, hit upon the plan of employing a check valve in the steam pipe, in a somewhat similar manner to the check valve arrangement common on boiler-feed pipes. The construction of this valve, which is shown by the cut, Fig. 3, is as follows: In a cast iron body piece, resembling that of an ordinary steam stop valve, is fitted a gun metal seating with valve, A, which opens downward, and is held lightly against the seat by being provided with a float, B, connected to it by a small spindle, and swimming in the reservoir of mercury in vessel, C. This check valve is, of course, placed on the steam pipe leading from boiler to main pipe, and by preference with the usual stop valve intervening between it and the boiler, the steam flowing through it, when the boiler is at work, in the direction of the arrows. The size of the float is so proportioned to weight of valve as to hold it gently against the seat, so that a very slight excess of pressure in the boiler to which it belongs will depress it and allow the steam to flow freely through it; as soon, however, as the pressure in the boiler becomes equal to or less than in the main pipe, it will at once close and cannot by any accidental circumstances be reopened under the said condition of pressure. It is thus self-evident that it forms a complete safeguard against scalding, etc., to all engaged inside a boiler with those adjoining it in full work. Being placed in the position just named it also affords facilities for repairing the stop valve without, as is generally necessary, laying off the whole set of boilers. If the range of boilers, with which it is used, are provided with low water safety valves, it will, in the case of any one of the boilers losing its water, say during the night, prevent the steam from the rest of the boilers from flowing to the leaky one and becoming lost. A large number of these excellent valves are already in use and giving universal satisfaction.

The mercurial safety valves, which we illustrate, are also shown by Messrs. Hopkinson in the Paris Exhibition, and possessing, as they do, special merits, will require a detailed description. Although steam boilers have now been in use for so many years, yet quite a host of their safety valves (we might almost say the greater number of them) are little better than those first introduced, consisting essentially of a

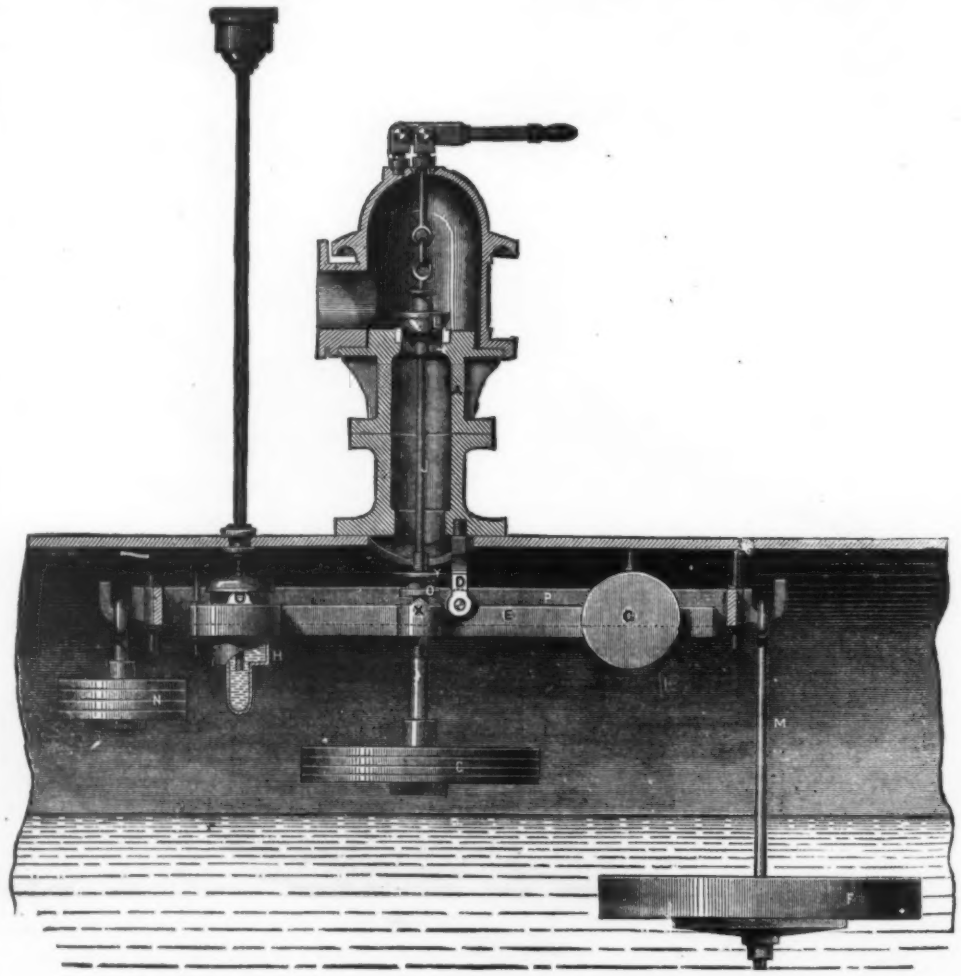


FIG. 2.—VALVE FOR OVERPRESSURE AND LOW WATER.

miter valve held down on its seat by a weighted lever, and their great defect of only lifting to a small extent with any given excess of pressure has but in few instances been remedied successfully. The stubborn fact that safety valves only lift to a very small extent necessitates the use of large valves (with correspondingly heavy loads to hold them down), as it is always desirable not to allow any great increase of pressure when blowing off all the steam the boiler can generate, as, for instance, after stopping the engine. It will not be out of place to remark here that with safety valves of the usual construction an increase in the diameter of the valve to, say, double the amount, will (on account of the small lift) only give about double the discharging power, although the area of the valve, and therefore the necessary load on it, is four times as great.

The valve illustrated by Fig. 1, in addition to its capacity for discharging large quantities of steam with but little rise in pressure, possesses the advantage that it cannot be tampered with while under steam, all the working parts being inside the boiler. A is the cast iron body piece secured to boiler, and provided with gun metal seat, on which the spherically-shaped valve, B, rests, and C is the weight suspended by the rod, J, upon which a collar, O, is secured; these combinations forming a common deadweight safety valve. From the joint, D, a lever, E, is suspended, which, by a loop formed at about the center of its length, encircles the rod, J; a pair of knife edges, X, touching without pressing hard

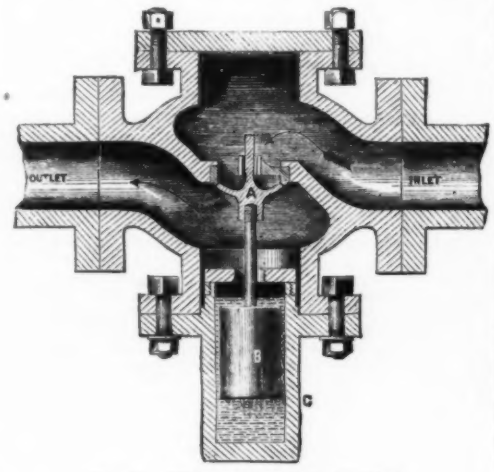


FIG. 3.—STEAM VALVE CHECK.

against the collar, O. Another loop, at left hand end of lever, surrounds and supports a cup, H, which is nearly filled with mercury, and is counterbalanced by the weight, G. The tube, K, with enlarged open mouthpiece, L, passes through the shell of boiler, dips into the cup, H, and is of such a length that at the intended working pressure a portion of the mercury shall be forced just up to the bottom of the vessel, L. The counterbalance, G, is fixed in such a position that under the above conditions it will just counterbalance the remaining mercury and cup, H. It will now be easily understood that even a slight increase of pressure above the normal will force a large quantity of mercury into the vessel, L, thereby reducing the weight in cup, H, and giving G a preponderance, which will assist in lifting the valve by pressing against the collar, O. By proportioning the absolute dimensions and the relative internal diameters of cup, H, and vessel, L, any required amount of lifting power can be secured, so that a maximum of discharge can be obtained with a minimum increase of pressure. On the other hand, as soon as the pressure is reduced to its normal extent, the mercury will have again returned to the cup, H, and as, therefore, not any pressure is now existing against collar, O, the weight, C, must close the valve completely. There is obtained, then, by this ingenious combination, a valve which, although comparatively small, will discharge a large amount of steam with but little increase in pressure, and again close as soon as the pressure is reduced to its normal amount. By a simple hand lever, as shown, the valve can be lifted before the full boiler pressure is obtained, but no excess of weight can be placed upon it. This combination can, we understand, be applied to any of Messrs. Hopkinson's ordinary low water and high steam valves, thereby greatly increasing their power.

Fig. 2 shows the mercurial valve just described, and which is for overpressure only, combined with the low water apparatus which Messrs. Hopkinson have long manufactured. Hinged to the same joint, D, which supports lever E, is the lever P, which is loop-shaped for the whole of its length, and provided with similar knife edges to those on lever E, but bearing against a larger collar, Y, on the spindle, J. From one end of the lever the float, F, is suspended at "Low Water Level," and from the other end the counterbalance weights, N. As long as F is immersed, and therefore partly carried by the water, the stop pin at right hand end of the lever will bear against shell of boiler and not any pressure will be exerted on the collar Y, but as soon as the water level sinks so that the float, F, is not any longer supported or only partly supported by the water, its preponderance over N will cause a pressure against Y and lift the valve. The arrangement, which prevents overpressure only, is exactly the same as that just described, and the letters of reference are the same as on Fig. 1. The whole being inclosed within the boiler shell it appears impossible when once set right that any harm can come to the boiler from either excess of pressure or shortness of water, and the arrangement, it appears to us, requires only to be well understood to be thoroughly appreciated.—*Iron*.

NEW FURNACE FEEDER AT THE PARIS EXHIBITION.

WE illustrate, from photographs, a new form of furnace-feeding apparatus, designed by Mr. Holroyd Smith, of Halifax, Eng., and which is shown at the Paris Exhibition by its makers, the Helix Furnace Feeder Company, of Lancaster. The arrangement contains some points of interest. Fig. 1 shows the front of the fire-door and the driving gear for the feeding apparatus. Fig. 2 shows the top of the grate, with the back of the furnace front and door. It will be seen (Fig. 1) that a cast-iron trough is placed across the furnace front below the door, to which trough fuel is passed through a hopper, placed sufficiently on one side to allow the door to be opened as usual. Along this trough lies a spindle, carrying two rough cast-iron worms, which receive an intermittent motion from the little link seen to the right in Fig. 1, and so serve to distribute the fuel sideways. Below this cross spindle lie the ends of three large cast-iron taper screws (one of which is shown separately in Fig. 3), which work in troughs carried along nearly the whole length of the furnace. On the front of each of these is a screw wheel gearing with a worm on the cross shaft seen in Fig. 1, which receives a continuous rotation from one of the pulleys shown. A fourth screw wheel (the one to the left in Fig. 1) is driven from one of the others, and is for the purpose of communicating a slow reciprocating motion to the firebars, in the direction of their length. Each of the four wheels is fitted with a clutch, so that each can be thrown out of or into gear separately if required; the clutches, together with the frame containing the outer bearings of the spindles, being omitted in our engraving for clearness' sake.

The grate itself (see Fig. 2) consists of three pairs of broad perforated bars, having projecting pieces at their back ends, which serve as guides for their longitudinal motion. Between and below each pair of bars, in a cast-iron trough (see Fig. 1), works one of the feeding screws. The back part of the grate is a perforated rectangular casting which can be tilted by the hand lever just seen below the front of the apparatus in Fig. 1.

The screws are intended to carry the fuel gradually and continuously forward and upward, air being admitted through the bars. The fuel will thus get gradually heated, and it is expected that the hydrocarbons will be burned to considerable advantage, a matter certainly of great importance in dealing with many of our coals. At the same time the combustion should be perfect enough to prevent, practically, any smoke formation. Any ash or unburned matter accumulating at the back of the grate can be removed by tilting the back piece, as shown in Fig. 1.—*Engineering*.

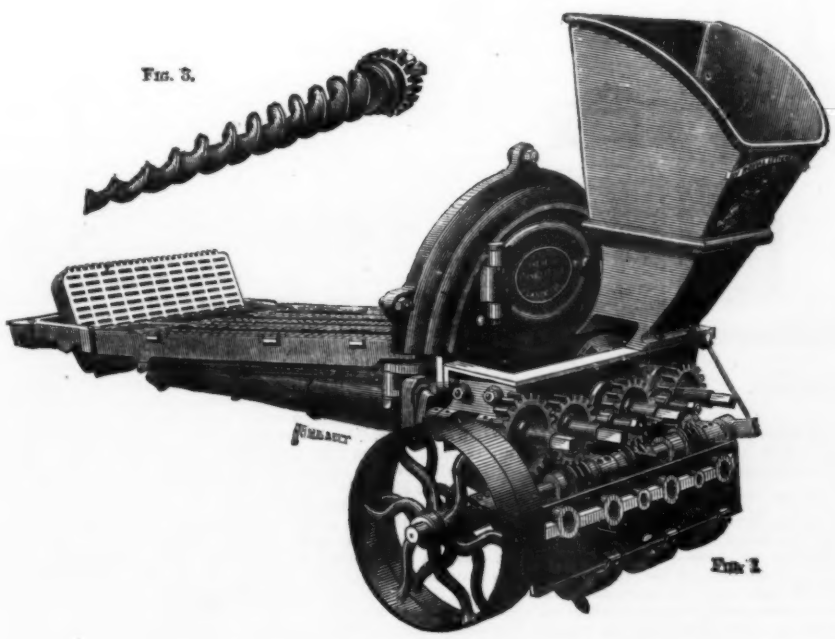
NEW TORPEDO BOATS.

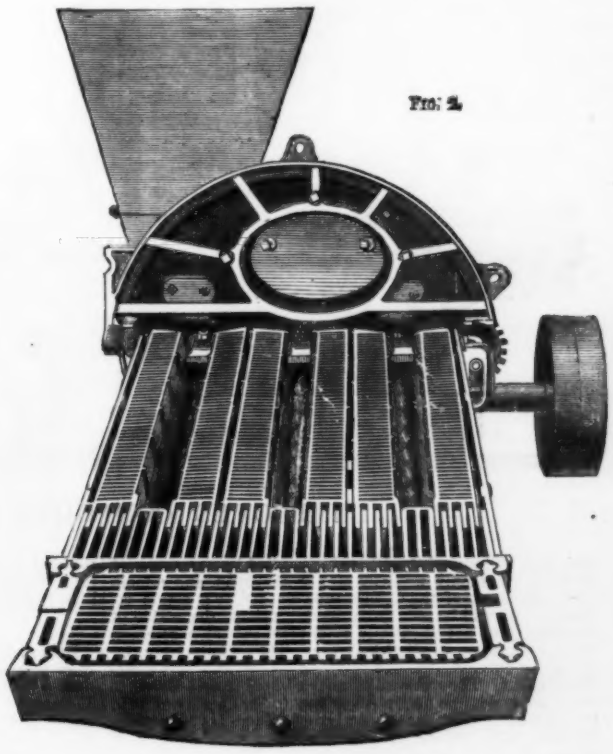
A REMARKABLE series of experiments has just been concluded at Cherbourg by the successful completion of the three hours' trial of the last of a set of six torpedo vessels, which Messrs. Thornycroft & Co. have just delivered to the French Government. These vessels are somewhat similar to the improved "*Lightnings*" which that firm is now building for the English Admiralty, being 87 feet long over all, by 10 feet 6 inches beam, and drawing about 5 feet 6 inches of water. They are made of thicker plating than the original *Lightning*, and differ from her also in having the rudder placed abaft the screw—an arrangement which, it was feared, would occasion considerable loss of speed in the vessels, and which was only introduced at the urgent request of the French Government. By somewhat modifying the construction of the hull and introducing some improvements in the machinery, which practically secured an increase of available power, this fear, as will be seen from the following statement of results, has been completely dissipated, and the boats have in some cases attained a higher speed than the *Lightning* did on her trial. The results actually obtained were as follows:

No of Boat.	Speed on measured knot. Knots.	Speed on three hours' run. Knots.
54	18·482	18·661
55	19·423	18·734
56	18·441	18·963
57	18·379	18·165
58	19·153	18·405
59	19·307	18·836

The runs on the measured knot, six in number for each boat, were made alongside the Breakwater at Cherbourg, and the three hours' run were made in the open sea between Cape la Hogue on the one hand and Cape Barfleur on the other. The differences of speed as ascertained are accounted for by the condition of the bottoms of the boats and the state of the wind and sea on the days of trial. The speed contracted for was 18 knots per hour, so the contractors have amply fulfilled their obligations in that matter. The consumption of coal at full speed was found to vary from 18 cwt. to 1 ton per hour, and the bunkers were capable of containing 5 tons of coal. The actual amount of coal carried on the trials was only that required for a three hours' run. Steaming easily, the consumption was found to be very light—one of the vessels having made the voyage from Chiswick to Cherbourg in twenty-two hours on a consumption of 2½ tons of coal. The weight on board, in addition to the 3 tons of coal required for steaming, consisted of a crew of ten men, with stores, etc., including even a spare propeller and a weight equivalent to the weight of the torpedo gear to be used on the vessel, and fixed in the position that gear will occupy when the vessel is on service.

The primary object of the French in having these particular boats is of course the defense of Cherbourg; but it does not require a great amount of foresight to perceive that boats which are capable of steaming from one end of the Channel to the other and still having coal for a two or three hours' run at full speed will not be confined to the defense of any particular port, but will, in conjunction with larger vessels, be employed in offensive operations which will leave little to be done in the way of actual defense. Engineers and stokers accustomed to other classes of engines and boilers will find some difficulty at first in getting the power, and consequently the speed, which Messrs. Thornycroft and Co.'s men obtain; but this is mainly a matter of practice, and the French officers of the "Défense Mobile" are most assiduous in their efforts to acquire information regarding their new boats, and to practice their men in the working of them. Organization is principally what is now required to convert these boats, when properly armed, into a most important means of national defense.

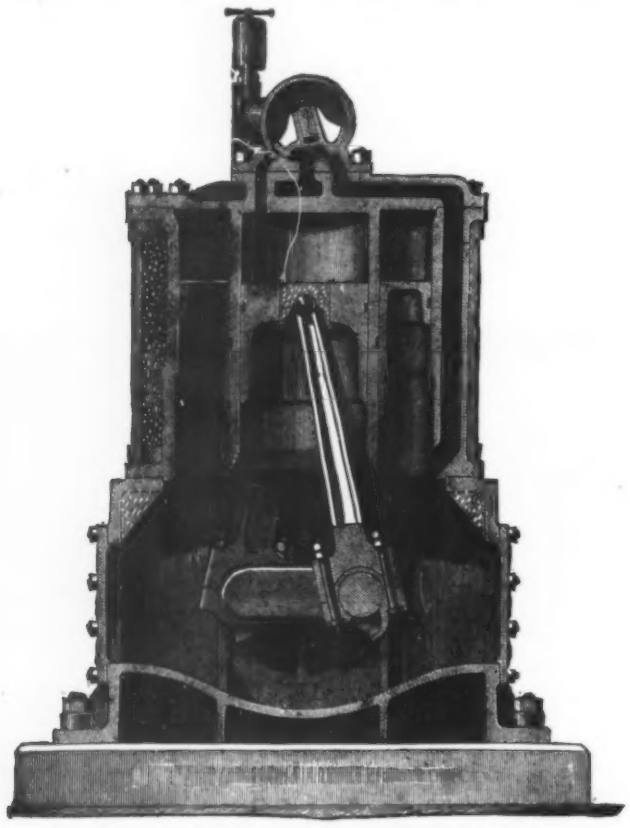


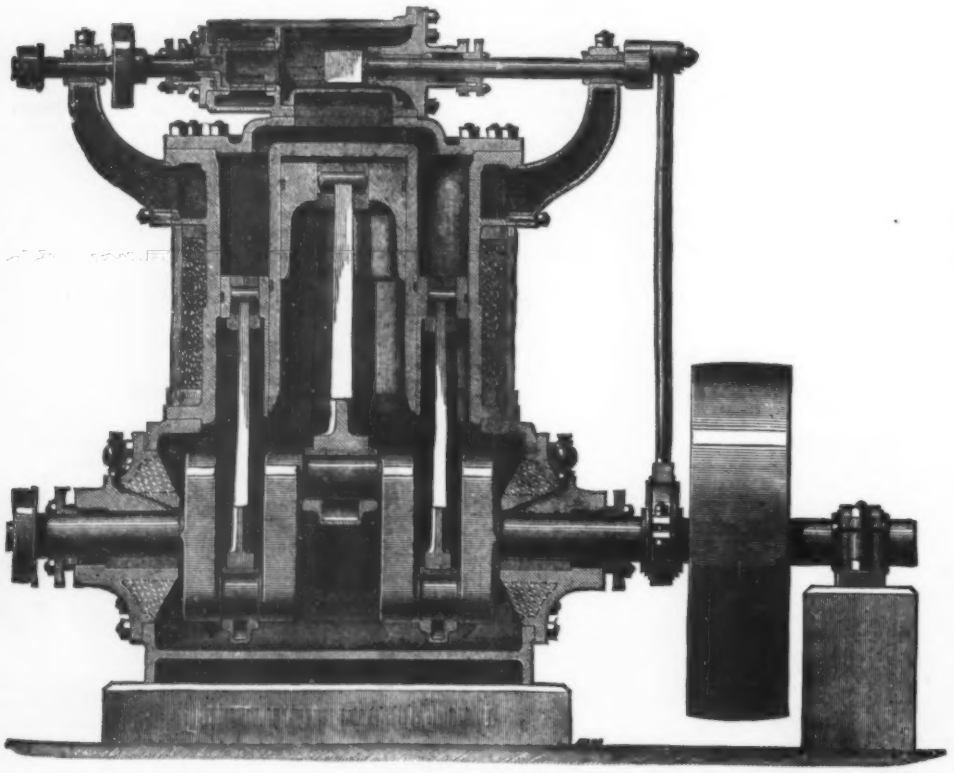


NEW FURNACE FEEDER.—AT THE PARIS EXHIBITION.

BROTHERHOOD'S COMPOUND ENGINE AT THE PARIS EXHIBITION.

Messrs. Flaud & A. Cohendet, of Paris, who have a capital show of small steam engines at the Exhibition, exhibit among them a compound engine designed by Mr. Brotherhood, which we illustrate below. It will be seen from our engravings (which give a longitudinal and a cross section of the machine) that the engine, which is very simple in its construction, is of the annular compound type, with cranks opposite each other. It has only three principal castings—the lower frame, the low pressure cylinder body and the low pressure cylinder cover, and high pressure cylinder, which are cast in one. The valve chest is bolted on to the cylinder cover, in which the (very short) ports are cast. It





IMPROVED COMPOUND ENGINES.

contains a cylindrical throttle valve worked by a governor of the form commonly used by Mr. Brotherhood, and a main valve somewhat of the Corliss type worked by a single eccentric. As will be seen from the engravings, the action of this valve does not essentially differ from that of a common valve working on a cylindrical face. The cylinders are single acting only, and the one valve serves for the whole steam distribution. The exhaust steam is allowed to pass down to the space under the piston on its way to the condenser or to the open air. A reasonably early cut-off can be thus easily obtained in the smaller cylinder, the other taking steam, of course, during its whole stroke.

The design of the connecting rods resembles that used in Mr. Brotherhood's three cylinder engine, the rods here, as there, being always in compression. A three-throw shaft is used, the bearings being in covers in the lower casting, and each has a stuffing box and gland at its outer end. The spring rings for the inner side of the low pressure piston are, it will be seen, placed in a recess in the cylinder instead of in the piston, the low pressure piston being made with a deep trunk, against the interior of which the rings can work. This is a very neat arrangement, and gets rid of a trouble which has been previously experienced in the packing of annular pistons.

The engine exhibited at Paris differs slightly in the arrangement of the valves and governor from that shown in our drawings, which represent a somewhat improved design used in the machines now in course of construction. It has cylinders of 0·25 and 0·50 meter (9·84 ins. and 19·68 ins.) diameter respectively, and is intended to indicate 50 horse power when running at 500 revolutions per minute. The Paris engine runs very quietly, it is neat and simple in design, takes up little room, and is well constructed.—*Engineering.*

By way of utilizing tinners' waste, the *Moniteur Industriel Belge* proposes to put the scraps into a revolving cask, along with a suitable quantity of sharp sand and quicksilver. The tin is supposed to be scraped off the iron by the sharp angles of the sand, and then taken up by the mercury. The whole process does not take above three-quarters of an hour. The *Chemiker Zeitung* observes that with the present low price of tin, and the high price of mercury, a portion of which will be inevitably wasted, this invention has small prospects of a successful application.

THE PORTUGUESE PHOTOGRAPHIC PRINTING PROCESS.

Heliogravure after the Copperplate Style.

Chromated Gelatine Process.

Reproduction (Without Half-Tones) of Engravings, Printed Matter, Manuscripts, etc.

A perfectly level and polished copper plate is coated with chromated gelatine. To dry the films a very simple apparatus is used, consisting of a sheet of cast iron seventy-five centimeters wide, moved quickly or slowly about in a box by means of a crank. Under this movable sheet of iron several gas burners are placed, and the gelatinized plate is laid on the iron and moved about until the film is dry.

The exposure is given either in the sun or by electric light (produced from a Gramme machine) under a positive *cliché*. The electric light is preferable, as it furnishes extremely sharp and very fine prints. The *cliché* must be very good, but it is not necessary that it should present such sharp contrasts as are required for photolithography—these, indeed, are here rather objectionable than otherwise; still the *cliché* must be pretty powerful and rich in details.

The picture is etched with chloride of iron, which, on the one hand, renders the gelatine insoluble, and, on the other, attacks the copper in inverse proportion to the action of the light. The perfectly-lighted parts of the gelatine act like an etching-ground. If there are both very broad and very fine lines in the drawing the former will not be broad enough to print from; one must then either deepen them with a graver or etch these lines again in the manner to be hereafter described.

Reproductions from Nature: Engravings with Half-Tones.

This time the level and polished plate is first dusted equally over with finely pulverized resin, and then gently warmed in order to make the resin sticky and cause it to adhere to the plate. The latter is then coated with chromated gelatine in the usual way.

The exposure under the positive *cliché* takes place either in the sun or by electric light. The back and corners of the plate are varnished, and any retouching that may be required is given. The plate is now placed in a solution of chloride of iron, which quickly penetrates the gelatine in the unexposed parts—more slowly the half-tones—and leaves the fully-lighted parts unchanged. The resinous powder lying upon the metal gives a fine granularity of texture, without which the picture could not be printed. The resinous powder, however, does not, unfortunately, admit of getting at the same time both powerful tones and delicate half-tones. The picture is seldom sufficiently dense, and when that is the case the outlines are almost always of exaggerated sharpness. This principally arises from the fact of the granularity of the plate not representing with the same good effect the different parts of the picture. This fault may be somewhat lessened by biting in the stronger tones with a strong solution of chloride of iron, and the half-tones with a weaker solution; or, better still, by etching the same plate twice, for which two *clichés* will be required, differing only in the amount of contrast in the tones that they offer; one must be weak and one strong. It should, however, be remarked here that on account of the exactitude with which the two pictures have to be placed one above the other this double operation presents great difficulties, and can only be successful in the hands of a very skillful operator.

According to the latest experiments, an insoluble, dark granular substance may be added directly to the chromated gelatine without affecting either the gelatine or the chloride of iron. (Pounded earthenware has stood the test.) By this procedure the details are more perfect, and the whole is richer and finer than when powdered resin is used.

Asphalt Process.

Reproductions of Pen and Ink Drawings, Prints without Half-Tones, Manuscripts, etc.—When there is a question of reproducing very fine work, it is decidedly best to work according to the chromated gelatine process given above. Geographical charts, maps, and that sort of thing turn out best with asphalt.

A solution of asphalt in benzine and oil of lavender should be prepared of such a consistency that this varnish, even when thinly put on, resists the etching water. It is poured like collodion over the copper plate, and dried with warmth. This plate is exposed under a *cliché*, either in the sun or by electric light. Should the plate, after being exposed, be still warm, it must first be allowed to become cold, and then be dipped in turpentine until all the asphalt which has not been affected by the light is dissolved. When the drawing stands out clear, then proceed to etch it with aqua fortis.

Zinc Etching in Relief.

The object of this process is the production of a metallic *cliché*, which may be used with type in the letterpress printing press; that is, may replace the as yet generally-used woodcut. The drawing may be produced on the asphalt with chromated gelatine directly either by hand or by photography, or by transferring a fatty picture which serves to resist the etching.

In all these various cases the drawing must be strengthened, either by a special covering or in some other way before etching. The work is then almost limited to repeated rolling with ordinary lithographic rollers after each time of etching, however slight, over those parts of the metal sufficiently bitten in by the acid, in order to protect them from its further action. The further the etching proceeds the more difficult does this rolling become, because the ink must be forced as far as necessary into the hollows.

For this purpose an oven, having a cast-iron plate, is used as a table; this plate should not be made hotter than 200° C. During the rolling the zinc plate should be laid upon this hot plate. The ink then sinks because the heat makes it more fluid, and so it runs down and fills the finer hollows. The nitric acid must be used diluted at first, and for each succeeding etching it should be taken a little more concentrated. All the time the acid is etching it must be kept moving evenly, and as long as the plate lies in the etching tray the latter should be turned round regularly, either by hand or by a small steam engine.

When the first etching has gone on long enough the zinc plate is taken out of the tray and washed with a brush with benzine, turpentine, or petroleum, and a weak solution of caustic potash or caustic soda. It is then dried upon the not very hot plate of the oven and rolled; but only until the finest lines are filled with the grounding ink. It is then etched again, and one goes on alternately coating with ink and etching until the drawing stands out in sufficiently high relief. The faulty parts must then be corrected and retouched. The plate is now ready to be mounted upon wood,

and printed in the letterpress printing press, where thousands of proofs may be pulled from it.

In the following paragraphs a few words will be said of Gillot's high-relief etching process, which is now used in many establishments.

TYPOGRAPHIC HELIOGRAVURE.

For this process a zinc plate furnished with a coating sensitive to light is exposed under a negative. It is the quickest and cheapest process.

It is very important that good metal should be chosen; and the plates must be made *very level*, so as to lie close to the negative and to be equally rolled. The zinc also must be homogeneous in texture, so that the acid may act equally upon it. It must be very compact and have no rents, and it is well to beat it before using it, as that lessens the porosity of the metal and makes it stronger.

It is easily known whether the plate is flat enough if one look at the image of the picture as reflected in its upper surface and bounded by certain lines.

The thickness of the plate may be varied from one to three millimeters; the larger the picture and the greater the distance between the lines the thicker the plate should be. Too thin plates are often difficult to fasten down to the wood.

REPRODUCTIONS OF ENGRAVINGS.

Good typographic printing plates may be produced in the following way: The sensitive mixture should be put on the zinc plates in as thin films as possible, and after being dried it is exposed in the printing-frame under a negative and rolled with ink as before. This process requires great care and skill so as not to allow the picture to be spoiled, as the acid is apt to attack the gelatine. It is, therefore, advisable to take the first copy upon a sheet of tinfoil, as in the process given for photolithography, and to transfer the fatty picture produced upon that to the zinc plate, and then to etch. This process is to be recommended for making plates of large dimensions.

Generally the process with asphalt is easier and more to be depended upon. The asphalt itself must be rather hard even at a considerable heat, and must still dissolve almost completely in benzine or in petroleum whose boiling-point lies between 80° and 100° C. The watery contents of the solvent are previously removed by inclosing it with calcic chloride. The following solution is then prepared:

Benzine	100 grammes.
Oil of lavender	3 "
Asphalt	8 "

In order to find out the degree of sensitiveness of the preparation and its power of resisting oil of turpentine, which is used to develop the picture, coat a plate with the asphalt solution, let it dry, and lay upon it a figure cut out of black pasteboard; then expose from fifteen to twenty-five minutes to the action of the sun's rays. Now let the plate become cold, after which place it in a dipper and dip it into a vessel filled with cold turpentine. If after the lapse of a minute at most the figure shows sharp and clear, while the unlighted parts of the film are dissolved, then the solution is usable.

As the heat of the sun makes the asphalt sticky and might thus spoil the negative, it is well, before exposing, to rub both the negative and the asphalted zinc plate with a soft cloth and powdered talc. The negative ought also to be coated with a very hard varnish. Before removing the plate from the negative, after the exposure, it must be allowed to become quite cold; the cooling is hastened by cleaning the back with a damp sponge.

The admixture of oil of lavender hinders the solution from drying and makes the film equal in thickness. As soon as the solution is spread upon the plate lay the latter on the sheet-iron plate, mentioned at the beginning of *Ozomated Gelatine Process*, which has previously been covered with a smooth sheet of paper. This sheet-iron plate should be turned until the film no longer smells of the oil of lavender.

When the picture has been developed in oil of turpentine it should be well washed with water from a tap furnished with a rose, in order to prevent the development from going too far. If it be found then that all the asphalt on the unexposed parts has not been dissolved, the plate should be dried between sheets of fine blotting-paper, and dipped again for a few seconds into the turpentine, and then rinsed at once with a good deal of water. The zinc plate is now drawn through very dilute nitric acid, slightly gummed, and rolled with ink.

The vessel in which the picture is developed should be polished at the bottom, so that the impurities of the bath may not injure it. It should be filled with cold turpentine, and the plate, when it has become cold, is placed in it. The development often occupies but a few seconds. The picture must not be left too long in the bath, and one should bear in mind the time which is lost between the drawing of the plate out of the bath and the washing.

TYPOGRAPHIC HELIOGRAVURE WITH HALF-TONES.

The production of *clichés* in half-tones for printing in the letter-press press is still an unsolved problem; still the experiment about to be described may lead to good results.

Some substance, such as sugar, starch, carbonate of lime, or carbonate of lead, which is soluble in water or in nitric acid, is rubbed into a solution of asphalt in oil of lavender. This is rubbed down upon a palette to a uniform, doughy mass, and as much benzine is added to it as produces a fluid of sufficient consistency. With this the zinc plate is coated, but not too thickly. When this coating is dry expose as usual, dip it in turpentine, and when the picture is taken out of that put it immediately into a bath of dilute nitric acid, as if to etch it. The acid penetrates the resinous film by dissolving the substance which gives it granularity, and perforates it in inverse proportion to the protecting action of the light, thus bringing out the half-tones. This etching process should not be continued too long. Parts that have been accidentally stripped bare are to be covered with varnish or lithographic chalk. The plate is then rolled with grounding ink and etched as usual.

JOSÉ JULIO RODRIGUES.

INSTANTANEOUS PHOTOGRAPHY.

A VERY remarkable improvement in instantaneous photography has been recently introduced by Mr. C. Bennett—a discovery which promises to vastly increase the capabilities of the art of the camera. It is, as might be expected, an improved dry-plate process, in which bromide of ammonium and nitrate of silver are the active agents. Probably the severest test of any instantaneous (so-called) method of photography consists in obtaining a picture of falling drops of water; and this Mr. Bennett has succeeded in accomplishing by photographing the drops of water falling from a jug and trickling over a bunch of flowers. His pictures, when examined under a magnifying glass, exhibit the drops of broken fluid clearly and unmistakably, and are a complete triumph of the photographer's art. They show that the ripple of the waves, the discharge of a gun, and even a flash of lightning, are capable of being depicted upon a negative with accuracy, thus opening up a still wider field of usefulness to the camera.—*London Echo.*

PHOTO-ENGRAVING.

By DAVID BACHRACH, JR.

THE above heading, properly speaking, would include a great deal more than could possibly be embraced in a magazine article, even in the most condensed form. I therefore intend to treat only of the method practiced in obtaining relief plates in metal from line or stipple pictures.

Of the influence exerted by the various and steady improvements in photo-mechanical processes within the last fifteen years on the profession it is almost impossible to form an estimate. It has placed photography in the front rank of the graphic arts. Who that has seen the productions of the Albertype, Woodburytype, heliotype, and other similar processes for half-tone work, and the reproductions by photolithography, photogravure, and last, but not least, the multitude of newspaper and book illustrations by photo-relief plates, has not felt on beholding them that photography, as a profession, was worthy of the greatest effort and the most subtle skill, and that its practical application extended to almost boundless limits? And all these are produced by the direct agency of the camera.

Since the first rough proofs by Paul Pretsch, of Vienna, were exhibited, the progress in this branch of the art has exceeded the most extravagant anticipations. Very few can appreciate the patience and effort of the comparatively few workers in this direction—the difficulties, disappointments, and repeated failures that had to be overcome by them before success had crowned their efforts, as it must be remembered that all these inventors had to treat with a very peculiar and (until recently) unreliable agent—gelatine rendered sensitive to light by the chrome salts.

The following is the method employed for obtaining relief plates in metal from line and stipple work and engravings, as practiced by the Bachrach Photo-Engraving Company of Baltimore, and the Levytype Company of Philadelphia:

First, as to the original. When it is a print of any kind it should be in pure black, on a white surface, to produce the best results. When it is a drawing or original design it should be made with a pen in thick black India ink or color, every line clear and distinct, on white paper, or, still better, enameled cardboard, as the enamel can be easily scratched away for an erasure, or when a line is too thick, etc. The best results are obtained when the drawing is two or three times as large as desired, and the lines made in proportion, so as not to be too close or too wide apart for the proper effect.

The next and almost the most important part of the process (and this applies to photolithography as well) is the making of the negative. First, it must be extremely sharp to the edge, the lines being absolutely rectilinear, and only the best lenses can be used for this purpose. The sensitive plate must be absolutely plumb with the picture on the copying board, and the exposure must only be just sufficient to give absolutely clear glass in the lines. The opacity must be as great as possible in the lights, and for this purpose I will give a special method of intensifying. I will here remark that unless the negative comes up to these requirements all subsequent steps will result in failure. The best collodion for the purpose is that containing very little of the bromide and a large proportion of the iodide salts. I prefer a bath made in the usual way, and then fused to the "oily" state, with which method no doubt all are familiar. It should be neutral, or very slightly acid. It must be remembered that the result aimed at is the very opposite of what we strive for in our usual work—that is, we want absolute blacks and whites. The double sulphate of iron and ammonia is the best developer when used with a large proportion of acid, it having the least liability to deposit on the blacks. I use glycerine with my acetic acid No. 8 in the proportion of one ounce to one pound of the acid. It is also a help in this direction. The fixing must be done with cyanide of potassium, and the plate then thoroughly washed. I next flow over a solution composed of one ounce of sulphate of copper, two drachms of bromide of potassium, and twenty ounces of water, till the negative has assumed a white appearance all through, and then wash again thoroughly. I next *immerse* it in a dish containing a twenty-grain silver solution, slightly alkaline, till it is completely blackened, and then wash it again. If it is not intense enough yet, the last two operations must be repeated until it is. If there is any dirt on the glass (to avoid which use albumenized glass), or it has been over-exposed in the camera, the lines are liable to be covered more or less, and in this case it is worthless, as in such places the lines do not come up to the same plane as the rest of the picture, on account of receiving a much less exposure to the light in the next operation, for it should be remembered that every line on the printing block must come up to the same plane.

Next comes the preparation of the gelatine plates. Dissolve one ounce of Cox's or Nelson's gelatine in eight ounces of water, in a small portion of which one drachm of bichromate of potassium has been previously dissolved in a separate vial. After the gelatine has been dissolved by heat in the usual way this should be added, and the whole carefully strained. Put carefully cleaned glass plates on leveling shelves in a dark room free from dust, and level each plate with a spirit-level. Then pour the gelatine solution upon the plates to the proper thickness—this depending on the class of work desired—and keep the room at a uniform temperature until the plates are entirely dry. This is a very important operation, as the nature of the lines will be governed in great measure by the temperature used, as well as the exact amount of the chrome salt in the solution.

We can obtain lines varying from being round at the bottom to perfectly flat ones (the kind usually desired), and even to *cup*-shaped lines. This can be learned only by actual practice. After the plates are dried they should be wrapped up carefully and excluded from light and air. They will keep in this condition for two or three weeks, and sometimes even longer. The exposure under a negative must be conducted in such a manner that the rays of light fall constantly at right angles to the plate, for which purpose a long box arranged so as to have a parallactic motion similar to a telescope, and denominated a "heliostat," is used. In sunlight the exposure averages about ten minutes. On dark days we use a large condensing lens, under which we expose usually from four to six times as long as in the sun's rays. There must be absolute contact between negative and plate, consequently perfectly flat glass should always be used. After exposure the plate is immersed in cold water, and at once a curious phenomenon occurs. Those parts of the plate not exposed to the light *swell* by the absorption of water, while those exposed remain unaffected. This, it will be seen, forms the relief. As soon as this action has begun all over the plate, we plunge it into a twenty-grain silver solution till the relief is high enough, *but not a minute longer*, for if the action is carried too far the lines become rounded at the bottom, and sharpness is lost. This part of the process is very important, and is our original invention. We have patented this step particularly, as it is peculiar to our process alone. The advantage of this operation lies in the fact that it sharpens the lines, and allows of greater relief being obtained without injury—very important for practical printing qualities—which advantage is recognized by printers using our cuts, which they prefer on this account over those made by other processes. The film, becoming full of bichromate of silver by this step, obtains greater consistency and solidity, and is capable of standing more handling in the subsequent steps. We have thus far found nothing that could equal this method in the results obtained. In our original invention we now proceeded to prepare the plate for direct action in the electrotype battery, but we have abandoned this for a more practical method, the copper facing of the cut not allowing of such easy retouching and finishing.

After the plate is properly swollen it should be rinsed with water, and a saturated solution of the subsulphate of iron poured over it. At the same time plaster of Paris must be mixed to a proper consistency, the plate put upon a level surface, the casting irons adjusted, and the plaster then poured into the mould thus formed. This should be mixed very thin, like cream, and only enough to cover the surface poured on and air-bubbles removed, when the balance must be added and allowed to set till sufficiently hard, which will require from fifteen to thirty minutes. The irons may then be removed and the cast separated, which will generally come off perfect. If not, another must be made at once. Those lines that were sunk in the plate will be raised in the cast, which is then right, or, as we term it, a negative. From this we take another mould, by first covering it with a solution of one part of silicate of potash to three parts of water, pouring off the excess and allowing the surface to dry somewhat, and then making the mould by again placing the casting irons around it and repeating the former operation.

This second cast is then put in the stereotyping pan, and a metal plate cast therein. It is not within the province of this article to give a description of this process, it being really another business entirely. After the metal cast is completed it is routed in the wide spaces where the relief is not sufficient to prevent the roller from touching while being inked in the press, defects are corrected, and the plate improved wherever possible with the graver. It is then mounted on a level block of hard wood, type high, and is now ready for the printing press.

The entire operation I have described, from the making of the negative to the completion of the engraving, is often done in our establishment in four to six hours, when specially hurried, but we usually deliver work in three to four days from the time of receiving the order.

By the various processes of this kind, in the United States alone, there is probably produced as much work *as a thousand wood engravers could do if constantly employed*, and some of the work, such as very small reductions, etc., could not possibly be done by any other means. This has all been accomplished within the last ten years, and the field is constantly enlarging, more especially in the reproductions of foreign works.

I have endeavored in this article to give a brief history as well as description of the processes employed in this important branch of our art, and hope that more of those who have had experience in this line will give us the benefit of their knowledge.—*Photographic Rays of Light.*

SPECIFIC GRAVITY.

A KNOWLEDGE of the "strength" of various liquids and solutions employed in different branches of photography is frequently of the greatest importance, and a ready means of acquiring the needful information should be at hand in every photographic studio as it is in the laboratory of the chemist. But too many of the followers of our art are content, if they give a thought to the matter at all, to accept as correct the *reputed* strength of the materials obtained commercially, and in the matter of solutions in constant use (the negative and printing baths, for instance) they work a "rule of thumb" mode of calculating or guessing at the extent to which the solutions are deteriorated by use.

Under such circumstances it is not surprising that serious difficulties not unfrequently arise, and in the latter case the photographer has no one but himself to blame; but in the case of liquids such as alcohol, ether, nitric or sulphuric acid, which for certain purposes require that the strength or specific gravity be accurately known, the chemist is oftentimes unjustly blamed when it is accidentally discovered that the quality is not such as had been supposed. The whole of these substances are liable to rapid deterioration if badly or carelessly stored; indeed, even when the utmost precautions are adopted it is almost impossible to preserve anhydrous alcohol and ether or the most concentrated acids in the same state as when freshly prepared. The photographer, then, is almost equally blameworthy if, by neglecting to examine his materials, he incur failure from this cause.

The methods by which the strength or quality of different liquids may be arrived at vary according to the nature of the substance to be examined. In the case of saline solutions the most convenient method is to proceed by quantitative analysis, though if a table of densities can be procured the determination of the specific gravity is sufficient, provided the solution is known to be pure. But, as has often been pointed out, the application of the specific gravity test to such solutions as a negative bath which has been much worked is worse than useless, as the salts introduced into it by the decomposition of the soluble haloids in the collodion entirely upset the calculation; hence the "argentometer" is to be avoided. In estimating the strength of acids the chemist usually adopts the process known as *acidimetry*, in which the result is obtained by ascertaining the number of measures of a standard solution of alkali a given quantity of the acid is capable of neutralizing. For nitric and sulphuric acids, however, which are the only ones that require to be estimated to a nicety, the determination of the specific gravity answers equally as well, and the operation is much

more easily performed. For ether and alcohol the specific gravity test is the only one available.

Very few of our readers, we imagine, require to be told that the specific gravity of a substance is the weight of a given bulk of it at 62 degrees Fahrenheit as compared with an equal bulk of some other substance which is reckoned as unity. Distilled water is universally adopted as the standard for liquids and solids, merely on account of its uniform composition and the fact that it is always at hand or readily obtainable. At present we are not concerned in the specific gravity of solids, and shall, therefore, confine ourselves to a description of the various methods in vogue for determining the density of liquids such as fall within the experience of photographers, though it may be remarked that the same means are equally available to every description of liquid, whether it be a simple substance or a solution, and either heavier or lighter than water.

For many purposes connected with the arts and manufactures the result is attained by means of an instrument commonly known as the hydrometer, of which there are several forms, differing slightly in construction but identical in principle, which will be familiar to most of our readers in the "argentometer." These are chiefly useful in testing spirits, oils, saccharine solutions, and other liquids, the commercial value of which depends to a great extent upon their specific gravity, but are not so well adapted to the purposes of the chemist. The latter proceeds by ascertaining the actual weight of a known volume of the substance to be examined, from which the specific gravity is obtained by simply dividing the result by the weight of the same bulk of distilled water, each of the liquids being weighed at the standard temperature of 62 degrees.

The instrument employed for this purpose is called a "specific gravity bottle," and consists in its simplest form of a thin glass bottle or flask with a somewhat long and narrow neck, and of such capacity that when filled to a point in the neck (at which a scratch is made with a diamond or fine file) it shall contain a known weight of distilled water at the standard temperature. More delicate instruments are provided with an accurately-fitting glass stopper, through which is drilled a small hole, so that when the bottle is filled with liquid and the stopper inserted any excess will escape by the perforation, and the contents be always invariable in volume. A further refinement consists in the addition of a small thermometer, forming part of the stopper, for the purpose of noting variations in temperature in cases where the liquid cannot be conveniently raised or lowered to the standard of 62°. In very delicate experiments the chemist is frequently obliged to resort to special means which need not be described here.

The capacity of the specific gravity bottle is a matter of no importance, provided it be accurately determined, but, for the sake of convenience in saving subsequent calculation, one containing 1,000 grains is to be preferred. All that is necessary in that case after weighing the liquid is to point off three figures of the result as decimals, and the number thus obtained is the specific gravity required. Thus we find the weight of a sample of sulphuric acid to be 1845 grains; we mark off the last three figures, and we have s. g. 1·845. Or a sample of ether is found to weigh 720 grains; we place the decimal point before the first figure, thus—s.g. ·720. If a bottle of half the capacity be employed the final result is the same, but we have to divide the result by 500 (the weight of the same volume of water), or, which amounts to the same thing, consider the weight as a decimal number, and multiply by 2. So, with the same examples given above, we find the weights to be 922·5 grains and 361 grains respectively, and dividing by 500 we get s. g. 1·845 and s. g. ·720.

But even with the most perfect apparatus obtainable the result will be far from accurate if the item of temperature be disregarded, and it is here where we should expect those inexperienced in chemical manipulations to be most likely to fail. However, by adopting a slightly modified course, a result, which though perhaps not strictly accurate is sufficiently near for all photographic purposes, may be easily obtained. It consists in weighing the liquid to be examined and also the water at the same temperature (the normal temperature of the atmosphere, regardless of the standard), and working out the calculation with the figures thus obtained. It will be found very much easier to proceed in this manner than to produce the standard temperature and retain it throughout the operation, either in the cold of winter or in the late tropical heat.

In order to obtain as clearly as possible this assimilation of temperature, the specific gravity bottle should be filled with the liquid under examination, and plunged up to the neck in a vessel of rain water previously boiled and allowed to cool. After remaining a quarter of an hour or so the stopper is inserted, the surplus expelled, and the bottle carefully wiped and weighed. The s. g. bottle is then emptied of its contents, thoroughly rinsed at the tap, and refilled from the vessel in which it was previously immersed, and the second weight taken. Theoretically this plan is open to the objection that, as different liquids do not expand equally under variations of temperature, different results would be obtained in summer and winter with the same substance; but practically the error is so slight that for photographic purposes it may be wholly disregarded. An actual experiment performed during the recent very hot weather will demonstrate this.

We operated upon a sample of sulphuric ether, employing a specific gravity bottle of fifty grammes capacity. The particular sample of ether we found by a recent trial, carefully conducted, at the standard temperature to register s. g. ·725 (strictly speaking, a little more, perhaps ·7252). Under the conditions described above the weight of the ether was found to be 555 grains, and of the water 767 grains. Dividing the weight of the ether by that of the water, we have $\frac{555}{767} = ·7236$, or ·0016 below the true result—a difference which could scarcely be expected to cause any serious injury if totally disregarded. In like manner we found that a sample of so-called absolute alcohol showed a specific gravity of ·812, the real figures being a little higher. To show the result of disregarding the temperature—at least so far as concerns the ether—it may be noticed that the actual weight of water contained by the bottle at 62° is 771·7 grains, and adopting these figures the ether would show a s. g. of ·719.

In conclusion, those of our readers who wish to avoid the expense of a specific gravity bottle may construct a very efficient substitute at a small cost. Procure a narrow-necked, one-ounce stoppered bottle (the "squat" shape will be the more convenient), and file a groove down one side of the stopper, so as to provide a means of escape for the surplus liquid. This may be filled with distilled water and weighed at 62 degrees, or the absolute weight may be taken at each experiment as we have described. A counterpoise is easily made from a piece of lead or brass carefully filed down to the exact balance. In emulsion experiments, or in the manufacture of pyroxyline, such an adjunct to the laboratory will be found of very great use, but especially so in the latter case. We recently had occasion to doubt the strength of some acids we had been using for that purpose, when we found the nitric to be s. g. 1·36 and the sulphuric s. g. 1·67, instead of, as reputed, 1·42 and 1·85 respectively—a sufficient difference to entirely alter the character of the pyroxyline made with them.—*British Journal of Photography.*

INSTANTANEOUS PHOTOGRAPHY.

By ERNEST BOIVIN.

On the return of the photographic season I have resumed my investigations, which were suspended during the winter. I am now able to obtain with great certainty dry plates of extreme sensitiveness by combining either an ordinary emulsified collodion or a washed emulsion with gelatine bromine. The following is the method that I have adopted:

On a plate previously coated with a substratum of caoutchouc, so as to avoid bubbles, I flow a collodion emulsion; it is washed with cold water, and then laid in a pan of warm water. After draining it, I again flow over this sensitive film another one of a hot six per cent. solution of gelatine bromide, made with Kennett's pellicle dissolved in a liquid consisting of equal parts of water and beer. Finally, I lay it horizontally to dry in the drying oven. An exposure of a few seconds only is required, and I use an alkaline developer mixed with beer, to which I add some drops of ammonium glucoside. The image develops without any fog, and has a very marked intensity, and I have met with no instance of failure of any of the different operations.

One of the principal elements of success with the gelatino-bromide process I have observed to be the rapid and regular drying of the sensitive film. To effect this I have availed myself of the excellent directions of M. Odagir for the construction of a proper drying-box, and have introduced certain modifications, which, as they are of importance, I am glad to have the opportunity of making known. In my drying-box the air is admitted through a tube of about ten centimeters in length and from four to five centimeters in diameter; this is filled loosely with cotton-wool, so as to prevent dust being drawn in with the current of air when the apparatus is working. This current I produce by means either of a lamp or of water. In the latter case, the box is connected by an India-rubber tube with the upper part of a cistern of water hermetically closed. When the box is filled with plates for drying I open a cock in the lower part of the cistern, and a current of air is immediately set up. By means of this cock the flow of water can be controlled so as to increase or diminish the current of air, and in this way a rapid desiccation is obtained, and one which is regular and free from dust—essential conditions in the gelatino-bromide process.—*Moniteur de la Photographie.*

MEDICAL USES OF CARBOLIC ACID.

A Clinical Lecture delivered at the Norfolk and Norwich Hospital, England.

By PETER EADE, M. D., London, F.R.C.P., Physician to the Hospital.

SEVERAL cases are now in the hospital under my care in which you will have observed that carbolic acid has formed some portion of the medicinal treatment. At the present moment three cases of phthisical disease are using this drug in the form of inhalation, and one patient suffering from strumous sores is applying it locally in the form of lotion and of carbolized oil. Other cases of medical disease in which it has been used have also recently been under your observation, and I have therefore thought this is a favorable time for calling your attention to some of what may be termed the medical uses of this drug, apart from or in addition to its employment in the more purely surgical cases of disease or injury. Your familiarity with such surgical uses of carbolic acid I cannot doubt; but beyond these there are so many diseases, in which it is of service, which are either purely medical or at least quite commonly come under the care of the physician, that I shall not be stepping out of my province in choosing carbolic acid as the subject of my lecture to-day.

PROPERTIES OF CARBOLIC ACID.

This carbolic acid (or phenic acid, as it was formerly called) is, as you know, one of the products derived from the oil of coal-tar, and has a chemical composition of $C_{12}H_5O+HO$. It is met with either as an oily liquid or in the crystalline form, and has an acrid burning taste, and a strong odor closely resembling that of creosote. It is slightly volatile, and is readily soluble in water, oil, or glycerine. One of its most valuable properties is that of preventing the decomposition of animal tissue—a property which it possesses in common with salicylic, boracic, chromic, and other acids and substances; but it is more generally useful than either of these, because it is not only more certain in its action, but may be employed in a more concentrated form without risk of injuring the parts or tissues to which it is applied.

Carbolic acid is an antiseptic. It prevents putrefaction, or the destruction and resolution of organized animal tissue into its chemical elements. But how does it do this? or, rather, in what does this process of change consist? For a full demonstration of the potential causes of putrefaction I cannot do better than refer you to the able addresses of Dr. Roberts, of Manchester, and Professor Lister, of King's College, published last year in the medical journals, in which it is pretty conclusively shown that the active agent in such decomposition or putrefaction is a microscopic vegetable body called "bacterium." And although Dr. Richardson has expressed the opinion that the cause of septic or putrefactive change is a chemical or glandular rather than such a vital agent, yet I think the present state of our knowledge justifies me in telling you that a living and self-producing agent is the constant accompaniment and potential cause of such a change.

BACTERIA—HOW DESTROYED.

Not very much is known about the life history of bacteria. They are vegetable organisms which, under moderate powers of the microscope, appear as minute lines, but under higher powers are seen to be rod-like bodies showing a sort of jointing from imperfect transverse divisions, and having usually a slight vacillating movement. They have been found not only in decaying animal tissues, but in milk, in the blood, in urine, and in other animal substances. Ehrenberg and others considered them to be animalcular, but they are now generally believed to be of a vegetable nature, either algoid or fungoid.

Now, putrefactive or septic action consisting in a destructive change brought about by the life and multiplication of these little vegetable germs, antiseptic action is the influence exerted by substances in preventing such life and development—in either destroying this life or its living power of multiplying at the expense of the material which furnishes its pabulum.

MEDICAL PREPARATION AND ACTION OF CARBOLIC ACID.

Such a property has been found to exist (among others) in carbolic acid, and, because of its special suitability, this agent is the one now generally employed for this purpose in surgical diseases and operations. It may be used in various ways. It is too acrid, almost too much of a caustic, to be used in its undiluted form except in the smallest quantities; but dissolved in water, oil, or glycerine, it may be used of almost any strength that may be thought desirable. The weakest form of lotion commonly employed contains about one part of acid to eighty or a hundred parts of water; and from this dilute solution it may be used for ordinary purposes of any strength up to that of the glycerinum acidi carbolici of the London Pharmacopœia, which contains one part of carbolic acid to four parts of glycerine. For local use in limited quantity, however, it may be used of much greater strength even than this; and I am in the habit (as you have seen) of applying with marked advantage a glycerine solution of the acid to the granular and excoriated os and cervix uteri, of the strength of four parts of the acid to one part of the glycerine.

The efficacy of the acid in checking diseased or septic action appears to depend upon its being brought into absolute contact with the part to be acted on, and it would seem to exert no beneficial effect beyond the exact limit of the part so touched. The explanation of this is very easy when we remember that its action is the destruction of the life of the germs living and flourishing in and upon the diseased part, and probably also—in the case of a suppurating surface—some check to the exuberant growth and development of the rapidly-secreted mucus and pus and altered epithelial cells, which have unquestionably a certain amount of inherent independent life and vitality.

But besides its destructive influence upon the vitality of the bacterium, carbolic acid appears to exercise the same power of destroying other vegetable germs which are the intimate causes of various diseases in or upon the human body. You are aware that a large class of diseases of the skin are now known to be due to the parasite growth in the cutaneous tissues of different fungoid germs, and in many of these carbolic acid has been found to be of signal service.

SKIN DISEASES, BOILS, CARBUNCLES, FESTERS, RINGWORMS, ETC., CURED BY CARBOLIC ACID.

The diseases in which I have found the carbolic acid especially useful are: 1. All that class of local festering, pustulating diseases of the skin which are at once so common and so difficult to cure. They include all kinds of pustules, boils and carbuncle; sycosis, pustular acne and festering ringworm. 2. Such strumous sores (especially of the neck) as come under the care of the physician. 3. Excoriations of the os and canal of the cervix uteri. 4. Phthisis in its second and third stages, and cases of chronic bronchitis accompanied with more or less purulent expectoration.

HOW TO USE CARBOLIC ACID.

I have said that in order to be effective the carbolic acid must be brought into contact with the part to be acted on, and I doubt not that in many cases where it has been found ineffective the failure has been due to a neglect to insure this contact. In the pustulating and suppurating diseases of the skin I have mentioned it is never sufficient to apply the solution of the acid, of whatever strength, upon or to the outside of the skin. It must always be introduced into the interior of the sore or pustule itself, and so as to come sufficiently in contact with every part of the diseased surface. Of its efficacy thus applied I have now had a very considerable experience, and so certain am I of its curative powers in these cases that I state with the utmost confidence that all cases of boils and carbuncles in their earlier stages can be absolutely aborted and cured, while even in later stages their further increase can be almost surely prevented. For this purpose a very strong glycerine solution should be employed, and it is best conveyed into the interior of the pustule, boil or suppurating spot, by a new quill pen dipped into the solution, and introduced by a rotatory motion through its apex, where a sufficient aperture will generally be found. In carbuncles, which are necessarily larger, and have often several openings, several such introductions may be necessary, or, at a later period, threads of lint soaked in the fluid, may be passed with a probe well into all the sieve-like openings. Occasionally, as when the mass is large and solid, a watery solution of the acid may be injected with a hypodermic syringe into various parts of the hardened growth. The same plan of treatment is often quite effective in cases of sycosis, pustular acne, and festering ringworm. And it is doubtless so because it destroys germs which, living in the involutions of the skin, are the essential cause of these various diseases. In the case of acne, and of boils and carbuncles, the essential dependence of these diseases upon vegetable germs has scarcely been demonstrated,* but their mode of origin and growth, their whole life history, and their curability by such local means alone, go far to prove that they, like other skin diseases, are due to the development in the cutaneous textures or glands of parasitic growth. As, however, I have already published in the medical journals several papers on this subject, I will no longer dwell upon it now. Not long ago it was stated that the development of the vaccine vesicle could be prevented by the application of carbolic acid to the vaccinated sore. If this is so, it would seem highly probable that the same kind of destructive influence would be exerted upon the small-pox eruption if the acid were applied to the pustules before or during the process of their maturation. The process of introducing a little of the strong acid solution *into* the apex of each pimple would be tedious and disagreeable, but, if effective, it might not only save much disfigurement, but possibly even life itself. Darkening of the patient's room, blackening of the face, covering up the pimples with wet clay (as practiced by some savage tribes)—all expedients for preventing the free development of the local disease—appear to diminish its virulence somewhat, and possibly this more direct interference with the special virus might do much more to mitigate its severity. Various applications to the general surface have been tried and failed more or less completely, and Velpeau has advised the cauterization of the individual

* Mr. Startin has written that in a few cases of boils and carbuncles he has found cryptogamic vegetation like to that seen in sycosis, and I have recently had a case of small carbuncle, in which, among the masses of plastic and other cells obtained from its interior, I observed, on pressure, a cloud of small rounded granules suddenly to diffuse themselves in the fluid in the field of the microscope, which were undistinguishable from those of the Achorion Schoenleinii.

pimples with solid nitrate of silver; but I am not aware that carbolic acid has ever been fairly thus tried, and I recommend it to your consideration when cases of this dire disease come under your notice.

2. The healing of strumous sores may be frequently much expedited by the bringing into contact with their interior or open surface a sufficiently strong solution of carbolic acid, and old stationary sores will often at once begin to heal when acid is so applied. So, too, when they are first opened their immediate healing may sometimes be brought about by injecting into them a solution of the acid, and keeping the opening closed against the admission of air. This method of treatment, on a larger scale, has been advocated by Mr. Callender in the case of spinal abscesses, and some very successful results have been recorded.

3. In excoriation, or so-called ulceration of the neck of the uterus, the strong glycerine solution is a most valuable application, and in my hands has been far more efficacious than nitrate of silver or other usual caustics. In these cases the denudation of epithelium is, commonly, not only of the vaginal surface of the os, but it extends up along the canal of the cervix, and often (as Dr. Playfair has shown) into the cavity of the uterus itself. I have found no ill effect from applying the strong glycerine solution freely with a camel's hair brush within the cavity of the cervix; and, indeed, it is not only well and painlessly borne, but is often very effective in promoting the healing of the "ulcerated" surface. I have thought it possible that its undoubted efficacy may be partly due to a power of destroying any bacteria or other germs living in the uterine mucus, and by their presence irritating the secreting surface, and so preventing the formation of healthy covering epithelium.

4. In cases of phthisis which have passed their earliest stage, and in which the sputum is of a muco-purulent character, you have almost daily opportunities of witnessing the efficacy of carbolic acid inhalations. In three patients now in the hospital the cough has been greatly lessened by its use, while at the same time the secretion of purulent mucus has been greatly diminished in quantity. As you have seen, we employ it in the simplest fashion. We give the patient a solution of the acid in water containing ten grains to the tablespoonful. We tell him to add this to half a pint of hot (not boiling) water in a narrow-mouthed jug surrounded by a towel or handkerchief, and then to inhale this for about ten minutes; and we order the inhalation to be repeated three, four, or five times in the twenty-four hours, according to the necessities of the case. The inhalation can, of course, be made through any ordinary inhaler, or it can be used with the acid in more concentrated solutions, or in the form of spray; but I have found the above method not only simple and always available, but perfectly efficacious. In these cases, as in others, I believe the carbolic acid to act entirely by its local influence. The vomica of a phthisical lung contains two elements: (*a*) the muco-pus already secreted, and lying more or less free in the cavity; and (*b*) less perfectly formed and separated mucus, still attached to the pyogenic or secreting surface. As atmospheric air laden with germs is constantly entering with the breath into these cavities, and as this animal mucus is a fertile soil for these germs to develop in, it is almost certain that such tendency to settle and multiply upon it exists; and the power of carbolic acid to prevent such life and growth would well explain its efficacy. But it is also known that carbolic acid does in some way prevent the rapid production of new pus and mucus cells, and in this way, too, some of its good influence may be exerted. But, whatever the explanation, there is no doubt that the use of carbolic acid in the form of vapor is a distinct addition to our therapeutical resources in the treatment of this disease. Many years ago tar-vapor was in much repute for the same purpose. The greater efficacy of carbolic acid is probably due partly to its purity and partly to the greater concentration in it of the active detergent principle, upon the presence of which the beneficial influence on the disease depends.

I will only detain you further to-day by mentioning one other form of medical disease in which carbolic acid is of some small help to us: I allude to those disorders of the stomach which are not only accompanied with fermentation and the flatulence induced thereby, but which show the actual presence of another form of low vegetable life. In the decomposing contents of the stomach in some of these cases may be detected by the microscope immense numbers of a small vegetable growth called Sarcina ventriculi. These little bodies are observed in clusters of adherent cells arranged in squares, each square containing four, or some multiple of this number, and they often present an appearance which may be roughly likened to that of corded woolpacks. In cases of this singular disease some advantage is occasionally derived from the administration by the mouth of carbolic acid in doses of one or two grains; but as the presence of these bodies is usually, unfortunately, only the result and accompaniment of other and more serious change, its efficacy is generally proportionately slight.

I may mention to you that when carbolic acid is very freely applied to the surface of the body for any length of time, the urine is apt to become stained of a dark or blackish color. But although this symptom is one which at once challenges attention, it appears to be of no real or serious importance, and at once disappears on the withdrawal of the producing cause.—*Lancet.*

Dr. Eade's recommendations appear to be corroborated by the following reports of recent cases in this country, which we find in the *Medical and Surgical Reporter* of Philadelphia:

CARBOLIC ACID IN CARBUNCLE.

I WILL give you below notes of a case of some general interest:

Saw Mr. R. W. on June 3d, 1878, with a carbuncle about five inches in diameter, situated on the anterior part of the thigh, about six inches below Poupart's ligament, presenting the usual appearances. Thinking this a good opportunity to try carbolic acid, I filled a hypodermic syringe with 95 per cent. solution of the acid, attaching a large needle. A puncture was made in the center of the mass and the needle pushed in to the depth of about three-eighths of an inch, when ten minims were deposited, at three-quarters of an inch another ten minims were left, and ten minims more at one and a quarter inches. For a short time pain was intense, but soon subsided, without opiates. Ordered a large, warm flaxseed poultice. Saw patient again June 6th. Found the central part of the mass broken down, and suppurating very freely. No pain had been experienced since that immediately following the injection of the acid. From this time recovery was very rapid.—G. V. CHAMBERLAIN, M.D., *Birch Run, Michigan.*

I also have lately been treating a carbuncle. A young student friend called, some two weeks since, with a medium-sized carbuncle, near and posterior to the mastoid process. Said he had one a year ago that lasted and worried him some six weeks. I told him I was afraid he would go through the same worry again. Said he was getting ready for commencement and he couldn't study, and wanted me to try and cure it as quick as possible. As yet I thought there was no destruction of cellular tissue, although it was nearly a week old. I charged my hypodermic syringe with five drops of carbolic acid and ten drops of water, and inserting the needle quite into the center of the carbuncle, I threw in the injection. In three or four hours it was badly swollen, though not very painful. In twenty-four hours it was much reduced in size, and by the third day had almost entirely disappeared. Final result, abortion or resolution. The dose of acid was probably large, but it was effectual. I got one dollar in cash and ever so much gratitude. I am not writing this for the *Reporter*, but only giving you the successful treatment of a carbuncle by one injection.—L. J. HARLEY, M.D., *Wooster, Ohio.*

THE ALKALINE TREATMENT OF BURNS AND SCALDS.

DR. GEO. F. WATERS, in *Louisville Medical News*, after giving an account of the circumstances which led to his discovery of the power of alkalies to promptly relieve the pains and inflammation of burns and scalds, says that his mode of treatment is to apply to the burned surface bicarbonate of soda in fine powder if it is a wet surface; but if it is a dry burn, he uses a paste of bicarbonate of soda and water, or a strong solution of bicarbonate of soda in water, applied to the burned surface. This relieves sun-burns, as well as burns from hot coals, melted sulphur, hot iron, steam, etc. He says that the burned surface should always be disposed so that the blood can gravitate toward the heart, if possible, as otherwise a continuous pain may be felt, due to the dilatation of the blood-vessels from the weight of the contained blood. If bicarbonate of soda is not at hand, bicarbonate of potash is next best, and biborate of soda does as well, but is not often found handy.

DANGER FROM HYPODERMIC INJECTION OF MORPHIA.

FROM a statement in the *Philadelphia Medical and Surgical Reporter* we learn that a death has occurred in the city of Washington from the hypodermic injection of one-sixth of a grain of morphia, which perhaps is the smallest fatal dose on record. Dr. E. Fletcher Ingalls, of Chicago, who has taken the pains to investigate the evil effects that frequently follow the use of this medicine when used hypodermically, has received a large number of letters from various sources all going to confirm the conclusions at which he had arrived in a paper on this subject, published by him in the *Chicago Medical Journal and Examiner* of August, 1877. Considering the large percentage of the fifty-five physicians who had communicated to him the fact that they had had unpleasant or fatal results from the hypodermic injection of morphia, it would not be surprising if more extended and accurate statistics would show that this practice is almost as dangerous as that of the inhalation of chloroform, if indeed not equally so. Dr. Ingalls, in a supplementary paper, in the May number of the above mentioned journal, says:

"I know of no precaution which will render the hypodermic injection of sedative doses of morphia entirely safe; the medicine may be given in this way a thousand times without harm, but the next time it may be the cause of death. Nothing in the patient's history or general appearance can warn us of the danger, for we find fatal accidents among those who have formerly taken morphia with the happiest results. The danger seems to arise from rapid absorption, or injection directly into the circulation, and it is greatly enhanced by the impossibility of removing the poison."

Dr. H. Gibbons, who has written on the same subject in a recent issue of the *Pacific Medical and Surgical Journal*, offers no theories as to the cause of sudden death which sometimes follow this mode of using morphia, but gives some precautions that should be observed, without assigning any reasons for them. Some of the peculiar symptoms that have come under his observation are as follows:

"The patient sometimes complains that pain existing before an injection of morphia is made is within 20 or 30 seconds thereafter suddenly aggravated, but passes away in less than a minute, and is followed by the proper action of the morphia. Second, a distressing sensation, which takes the place of the pain, leading often to the expression that the patient feels as if dying, and likewise lasting but the fraction of a minute."

To return to Dr. Ingalls' paper: The author does not believe that the familiar rules laid down for the cautious use of the hypodermic syringe (*i. e.*, to "withdraw the point of the syringe slightly after the needle has been introduced as far as desired, to inject slowly," etc.) will necessarily prevent "the solution from passing directly into the circulation; and as to injecting slowly, probably no one would think of occupying more than five or at most ten minutes in the operation, which would not be long enough to prevent accidents from rapid absorption. So far as danger is concerned, the hypodermic use of morphia seems to stand in much the same relation to its administration by the stomach as the inhalation of chloroform does to that of ether; either method may be fatal, but the latter seems much the safer."

He says "it is difficult for those who have injected morphia subcutaneously for years without accident to realize that there can be danger from the practice; and so it is with chloroform, yet we all know that accidents happen from this drug even in the hands of the most cautious and skillful surgeons."

DISEASES OF THE EAR FROM BATHING.

Now that we are in the midst of the season in which the pleasures of bathing are being freely indulged in all over the country, a few words of warning in regard to one of the most frequent dangers connected with this sport may not come amiss, and this has been given us in a recent number of the *Medical Record*, by Dr. Samuel Sexton, Surgeon-in-Chief to the New York Ear Dispensary, etc. He informs us in this timely article that the ear is far oftener the seat of inflammation and resulting deafness from bathing than is generally supposed. Although the delicate parts of this organ are deeply seated in the skull and consequently protected from objects capable of injuring them, yet in any bathing which includes the immersion of the head they are very likely to be more or less damaged by the admission of water through the external auditory canal or the Eustachian tube. That bathing cannot be practiced as at present without danger is undeniable. It is shown by a glance at natural history that amphibia, whose life is passed indifferently in air or water, have the means naturally of protecting their auditory apparatus, but man is not so constructed, and therefore cannot practice diving or submerging the head with safety. He should never dive, at least if he desires to preserve his hearing. Whenever water finds admittance to the external auditory canal, if cold or salt, inflammation of the meatus alone may result; or if violently injected, as in surf-bathing, or long retained in the canal from diving, the disease may affect the drum-head and middle ear. When water is forced from the mouth and nostrils into the middle ear through the Eustachian tube, inflammation of the middle ear is almost sure to occur, even though the water be warm. Frequent exposures, especially in salt-water bathing, may be the cause of slight earaches, which, although usually neglected as unimportant, are very frequently the precursors of much deafness. When in the surf the bather should take the water upon his chest or back, closing mouth and nostrils, and being careful not to present the ear to the incoming wave. While swimming it is equally dangerous to receive the dashing water into the mouth or nostrils; a firm plug of cotton-wool in the ears is some protection. Dr. Sexton says that the fact that several thousand severe cases of ear disease thus result annually in New York city alone should be a serious admonition to all concerned, and that three of the sixty-five cases reported in his present article had dangerous cerebral complications should be a still further warning.

STRUMOUS DISEASE TREATED BY VOLCANIC VAPORS.

NORTH of Naples there is an extinct volcano called the Solfatara, the crater of which is easy of access to carriages or to pedestrians. From a number of fissures (called *stufe*), situated at different points in this crater, varying quantities of steam and vapor charged with sulphur and arsenic are constantly emitted.

Dr. Horatio R. Stover, of Newport, communicates to the Boston *Medical and Surgical Journal* an article in which he describes the benefits that have been derived by strumous and consumptive persons from the inhalation of these fumes. One of these cases was that of his own son, who began to improve almost immediately after resorting to the crater; but he also drank the waters found in the crater, containing some sulphuric acid. Dr. Stover states that the first medical use of these fumes (as far as he can ascertain) was made by Dr. Abele Franza, in 1871. A Russian gentleman, presenting a case of far-advanced tubercular disease, was removed from Naples to Pozzuoli (which is in the vicinity of the crater) that he might inhale the vapors. Improvement was said to have been immediate and permanent. A second case of acute tuberculosis was also relieved without a resort to any other means. Dr. Stover refers to papers by Prof. de Luca, who has made a great number of observations on the composition of the thermal mineral waters of this crater, and on the temperature and exhalation of its greater throat (the *fumarola*). The benefits derived from the treatment indicated in this article are supposed to depend upon the arsenic contained in the vapors

THE NEW DENTAL DEPARTURE.

By L. P. MEREDITH, M.D., D.D.S.

RECENTLY the equilibrium of the dental profession has become very much disturbed over what is miscalled the "new departure," and much of the space of the dental journals and much of the time of the conventions and associations are consumed in the discussion of the important questions involved. But the interests at stake being mostly of a demotic nature, it seems very unfair that the knowledge gleaned from the discussions should be retained esoterically by the members of the profession, while the people are left in ignorance of the facts and truths educed, which are so intimately connected with their welfare. This is because there exists no popular journal for the purpose of imparting dental knowledge to the public, and because very few comparatively have access to the periodicals intended particularly for the dental profession. It is by the desire to dispense this information to the greatest number of readers possible by a single paper on the subject that I am led to offer this contribution.

The term quoted above is really a misnomer, for there is not an element of newness in the "departure." It is a relapse into a former state; it is a slipping down the hill of advancement into the old ruts at the base on the part of those who have become discouraged at the inability of dental science to maintain some of the elevated positions occupied, and who have not tried to secure a footing at stations which, though not at such an altitude, are yet far above the starting point.

A few years ago, say a score, to express it in round numbers, cavities in the teeth only of a comparatively simple nature were filled, even by the best operators, with gold, owing to a scarcity of appliances, suitable preparations of gold, and lack of experience. Then gradually succeeded a period which has existed to the present time, in which, by the invention and introduction of cohesive gold, rubber dam for excluding moisture, clamps for retaining the rubber in position, saliva ejectors, reflectors, matrices, mallets, dental engines, and other instruments and appliances, it has been possible for skillful dentists to fill solidly and thoroughly with gold, large, complicated, nearly inaccessible cavities, that it would have been sheer folly to attempt before the introduction of the numerous auxiliaries mentioned. In short, it has been the rule among the most skillful dental manipulators that any tooth may be filled with gold perfectly, no matter how large the cavity or how difficult of approach.

While the beautiful polished tournures and other work of fictile perfection that have proceeded from the hands of patient, able operators have gratified their laudable pride and have excited wonder at the achievements of operative dentistry, yet the fact has become too evident that a large proportion of these highly skillful and artistic operations has not that durability which the patient might reasonably expect in return for his expense, loss of time, and long, unpleasant confinement in the dental chair. This result has caused a variety of feelings among members of the dental profession, their numerous patients, and those whose business it is to provide dental materials. It is extremely mortifying to those who have made it the aim of their lives to excel as skillful and eminent operators in gold. The lowering of the standard of dental perfection is a source of undisguised rejoicing on the part of old fogy operators and incompetent practitioners who have never had ambition nor ability.

Patients who permitted the ravages of decay almost to the destruction of their teeth before they placed them under

the care of the dentist, and who have expended much time and money, and have endured much pain and inconvenience, without succeeding in preserving their teeth permanently, are apt to lose confidence in all conservative dentistry; and those who make the insertion of artificial teeth a specialty are expecting benefits from their experience and influence.

Those individuals and establishments which have been engaged extensively for years in the preparation of dentists' gold to meet the great demand, and those which have supplied amalgam and other cheap plastic preparations, are awaiting anxiously the decision which must affect their interests so materially—the one unfavorably, the other favorably.

Lately a few members of the profession whose positions have been so prominent that their prestige is acknowledged and their influence is felt, realizing the truth that gold is inadequate to the permanent conservation of the teeth in many of the complicated cases referred to, have rushed blindly, recklessly, into the advocacy of amalgam, the same old, pernicious compound that was in common use before dental advancement, and which has all of the time been the main resort of quackery and incompetency. And this is what is denominated the "new departure."

The simple secession of these few members would be a matter of little importance if they would confine their erroneous views to their individual practice; but, like those who apostatize in religion or politics, they are exerting themselves to their utmost power to cause further defection.

I will not consume space in presenting proofs of the noxious qualities of amalgam and its unsuitableness as a material for filling. Its shrinkage, allowing recurrence of decay; its unpresentable appearance from discoloration; its injurious galvanic action, causing decomposition of fillings and tooth substance, and its baneful effects, local and systemic, from the mercury incorporated, are faults admitted by nearly all scientific dentists, and are testified to by too high authority to be contested.

We are certainly on the eve of a radical change in the methods adopted for conservative dentistry; but because the so-thought catholicon for dental decay, gold, has not fulfilled the requirements in all cases, we should not rush precipitately to the employment of a material that, even were it free from the highly objectionable features and injurious effects enumerated, still would answer only a temporary purpose for the arrestation of decay. Although in our rapid strides toward dental perfection we have been disappointed of some of our expectations, we should yield only that ground which is proved to be untenable, while we firmly establish ourselves in positions that we know can be maintained.

Experimentation and invention have striven to produce a material for filling that is capable of ready adaptation to every portion of the walls of a cavity; free from contraction; a non-conductor of thermal changes; of natural color; uninjurious to the teeth, mouth, or system; hard enough to prevent undue attrition from mastication, and insusceptible to the action of medical or chemical agents that may at any time be present in the mouth. Any substance possessing these qualities and attributes would be considered perfection. Various ones have been presented and thoroughly tried, but most have been found wanting in some respects.

Long and thorough experience with them has educed the following incontrovertible, incontestable facts relating to the efficiency of different filling materials. All of the assertions are based upon the supposition that the work is done by skillful, conscientious operators; where others are employed beneficial results cannot be regarded as certain in the use of any material. Ordinary attention is expected from the patient also; where people are utterly negligent in regard to cleansing their teeth it may be considered as certain that decomposing food and vitiated secretions will undermine the best fillings in the course of time.

1. *Gold* will permanently preserve the teeth when placed in simple cavities with strong, thick walls of enamel, the dentine not having been exposed so long as to be decomposed to a considerable depth. Between the approximating surfaces of teeth sufficient space must be left for the patient to keep the fillings clean. Gold fillings in cavities of the most extensive and complicated nature will often save the teeth permanently, with ordinary carefulness in cleansing by the patient, if the filling or the surrounding tooth substance does not become broken by use; but on the other hand, they will very frequently fail in a few years, owing, doubtless, to the unhealthy condition of the dentine, caused by long exposure before filling. Frequently, where such large fillings are inserted, the frail edges of the tooth or a portion of the gold will be broken off in mastication or by mechanical violence, an exposed place being thus formed for the lodgment of food and the fluids of the mouth, which renew decay. Often in such instances the breach cannot be repaired without the re-insertion of the entire filling. Gold being one of the best conductors of heat and cold, very often unpleasant sensations are felt in the tooth for a while after filling, when hot or cold substances are taken into the mouth. Occasionally, from this cause, inflammation and death of the pulp of the tooth, with subsequent discoloration and abscess, occur; but trouble of this kind is so infrequent that it can scarcely be urged as one of the objections against gold. The color of gold, though very unnatural, seldom causes dissatisfaction. As far as complete adaptation to the walls of the cavity, freedom from shrinkage, purity, innocuousness, unchangeableness, and resistance of mechanical and chemical action are concerned, gold is absolute perfection. While its expensiveness in small cavities is not so great as to deter any one from having it who can afford dental services at all, yet in large, compound ones it often presents an insuperable barrier to its use. There is no way of overcoming this difficulty without slighting the operations. A filling requiring from several hours to an entire day's time must necessarily be costly.

2. *Tin Foil* answers most of the requirements, and is nearly as good as gold in simple cavities. In large contour fillings it cannot be used to advantage on account of its lack of cohesive or welding properties. It has one advantage over gold in its being a poorer conductor of thermal changes. In many cases it becomes discolored and partially disintegrates after some years' use. It is seldom used even for small fillings, as there is so little difference between its cost and that of gold, owing to the fact that it requires fully as much time and care for its insertion.

3. *Gutta Percha* compounds are excellent as temporary fillings, and sometimes last for years when not exposed to masticatory action. Hill's stopping may be taken as a representative of this class; it is entirely free from conducting properties; it is readily pressed into the cavity and built up to the form of the tooth by warmed instruments, becoming tolerably hard and tough as it cools. A large filling may be inserted at a trifling cost, in a few minutes, that would take many hours with gold.

4. *White Filling* is the common name of a polynomial compound known by the various appellations, osteo-plastic, osteo-dentine, os-artificiel, bone-filling, Guillois's cement, German cement, cement plombe, etc. They consist essentially of oxide of zinc, chloride of zinc, silex, borax, and coloring matters. Osteo-plastic may be taken as a type of all; it is coming more and more into favor every day; and it may be predicted, as it is ardently to be hoped, that the time will soon come when it will supersede everything else for filling in those complicated cases where gold filling has proved to be so expensive, tedious, and uncertain. It meets the list of requirements of a perfect material for filling the teeth more nearly than any substance known. A shade can be selected that approximates very closely that of the natural tooth. It is a non-conductor of thermal changes; it is pure and uninjurious to the teeth, mouth, and system; it allays sensitiveness of the dentine, which frequently requires especial medication in preparing for gold filling; it is not only susceptible of complete adaptation to all parts of a cavity, but it clings to the walls as mortar does to a petrous surface, thus bracing and strengthening a frail tooth, which is accomplished by no other material. In case of any subsequent fracture, fresh material may be added without removing the filling. A large cavity that would consume a day's time in inserting an expensive gold filling may be filled in a few minutes with the osteo-plastic. Decay around such a filling is an unknown occurrence. Its only fault is that it becomes washed out gradually at the exposed surface, frequently to such an extent in a year or so as to require an addition; but it often lasts four or five years without a renewal being necessary.

The additions and renewals might in the course of some years make the aggregate expense equal to or more than that of gold filling; but there would be no long, tedious operations, and there would be a certainty of no further decay under the filling. The presence of osteo-plastic in the tooth for a number of months, moreover, hardens the dentine and prevents tendency to disintegration, so that if gold is preferred subsequently to renewals it may be inserted with confidence that decay will be much less likely to recur. Osteo-plastic may be used also in many cases where the form of the cavity will allow it, as a coating over the dentine, and gold may be placed over it with the same assurance of permanent preservation.

In the use of this material it is only necessary to remove the decayed substance of the cavity, consequently the patient is spared those unpleasant and often painful operations for drilling retaining points as for gold. By the use of osteo-plastic for large, complicated cavities, and gold for small and medium ones, protracted, fatiguing operations, and extravagant dental bills, which are usually incurred with reluctance, will be among the experiences of the past. Gold, as before intimated, is preferable for simple cavities, because the preservation of the teeth is certain, and because even the small expense of additions and renewals in these cases would before many years exceed the cost of gold fillings.

For the filling of the temporary teeth and children's permanent ones when the patient is too young to endure fatiguing gold operations, osteo-plastic is simply invaluable. This material is pressed into the cavity in the form of a paste of putty-like consistency, and becomes tolerably hard in a few minutes; but to secure thorough lapidification and the utmost extent of durability it is necessary to protect it from moisture for some hours by some impervious coating. Very early failures of the filling may always be attributed to lack of care in this respect.

RECENT PROGRESS OF ENTOMOLOGY IN NORTH AMERICA.

MR. SAMUEL H. SCUDDER, President of the Cambridge Entomological Club, in his annual address before this organization, printed in *Psyche*, the organ of the Club, takes occasion to review the work done in this field of natural science during the year 1877 in North America. From this we make the following notes, the address being too long to quote *in extenso:*

The author remarks that histories of insects furnish the fundamental data upon which will be based much of the future progress of entomological science. In this direction Mr. W. H. Edwards has contributed some of the most important facts. In continuing his beautiful work on North American butterflies he has represented the transformation of the "Turnus" butterfly with rarest fidelity. Eleven drawings of the perfect insect appear, nine of the caterpillar, and one each of the egg and chrysalis. Mr. Edwards finds three broods of this butterfly in West Virginia. In the *Canadian Entomologist* the same writer gives us also the life history of the "Pharos" butterfly (*Phyciodes tharos*). Although one of our commonest species, we have until recently known nothing of its history. The eggs are laid in masses on asters; the caterpillars feed in clusters, and are at no period protected by a web. The winter is passed in the larval stage, and there are annually several broods of the butterfly. A curious fact was elicited by Mr. Edwards' experiments, viz., that caterpillars maturing in one season moult only four times, while those hibernating moult three times before winter and twice afterward. Prof. C. V. Riley has given us two or three fine histories of unusual interest. The first is a life history of a genus of the "blistering beetles" (*Meloidæ*), insects remarkable for their habits and extraordinary metamorphoses. These have already been described and illustrated by Prof. Riley in back numbers of the SCIENTIFIC AMERICAN.

Another discovery of Prof. Riley is that of the curious egg-masses of the common Corydalus (*C. cornuta*), an insect extremely interesting from its relationship to carboniferous types. The larva and pupa have long been known, but not so the eggs. These, as it now appears, are laid in oval masses, of two or three thousand, upon leaves of trees overhanging water or upon rocks, and are covered with a common white or cream-colored albuminous secretion.

During the summer of 1876 the Rev. H. C. McCook studied the habits and the architecture of the wood-ant (*Formica rufa*), the mounds of which are abundant in the mountains of Pennsylvania. He camped for nearly a week in the vicinity of a colony of nearly seventeen hundred hills, covering an area of twenty hectares. The mounds made by these ants are cones of greater or less regularity, generally three or four meters in circumference at the base and seven and a half to nine decimeters high. Not only do the hills appear to be grouped in large colonies, but each colony is made up of family clusters, probably the work of a single republic. The hills are mostly composed of earth brought from beneath, but the surface is strewn to a greater or less extent with bits of decayed wood, pine needles, and fragments of straw, though not to the extent described in the nests of the European ant. This material is brought in by surface foraging. The nest is honeycombed through and through with galleries, mostly in horizontal strata, but show no such enlargement at special points as occurs in European hills. When the nests are injured they are immediately repaired, not by adding grain to grain to make a solid mass, to be afterward mined by galleries, but by constructing these galleries at once with little pellets, formed of a few cemented grains of earth, fastened to the parts already in place. In this way arches are sprung at needed points, and galleries are formed by filling in the spaces between the arches. In case of great damage the work goes on simultaneously from many centers by springing arches from piers erected at symmetrical intervals. In this way, too, stories are added to the structure. The work goes on with surprising rapidity, and mounds half the size of the mature hills may be constructed in a single year; but when once they have reached the normal size a period of thirty years may show little change. A curious fact was noticed in the orientation of the mounds—that while they were nearly conical, the longest face of the cone lay toward the west and its steepest slope toward the east. This peculiarity was only noticed in the mountains, and was not invariably true, but obtained as a general rule, whatever the slope of the ground.

Huber states that these ants close the approaches to their nests at night and open them again by day. Forel says that they seem to close them only when they appear to have no further use for them. Mr. McCook found them always open. He found the ants both feeding and building at night, their activity in building clearly depending on the moisture of the ground. When the nights were cold he found the ants torpid on the trees, beside their aphid flocks, just as the cold had surprised them. Observations in midwinter show that the colonies then remain still active in the galleries beneath their mounds; at the same time the interstices of the mounds may be occupied by the hardier white ants and by cockroaches. The paths diverging from the hills invariably lead to plants or trees occupied by colonies of aphides. These are visited by immense numbers of ants, which gorge themselves with honey-dew and return and feed the occupants of the nest. Mr. McCook was surprised, however, to see how few of these "repletes," as he styles them, actually returned to the nest, and was thus led to the discovery that many were stopped on their return by hungry "pensioners" emerging from the galleries, and were compelled to disgorge their sweets, so that queens, males, and young ants at home must have fared ill. Mr. McCook was unable to obtain any show of fight between these ants, excepting that individuals which had fallen into water (which is supposed to destroy their odor) were always violently attacked by their *confrères*. Colonies from distant hills were thrown upon a nest while it was swarming with a mass of ants, but not the slightest sign of hostility could be induced, the imported ants always melting into the general community as if at home.

Experiments on longevity and vitality of insects have been made by Messrs. McCook, Rathvon, Coleman, Packard, and Dimmock. Those of Mr. McCook, on vitality of ants, have already appeared in this journal.

From experiments made by Mr. Trouvelot on the use of the antennæ of insects, he concludes that the sense localized in these organs cannot be regarded as simply that of touch, of hearing, or of taste, nor can it be regarded as uniting the complex functions of these senses; he would rather regard it as a sense of direction or orientation.

Unusual and unexpected variations of form in some insects have been described by several observers, viz., Messrs. Edwards, Siewers, and Andrews.

Mr. Edwards has given us a continuation of his experiments on the effect of cold in changing the form of certain butterflies. Experiments were made on the Tharos, Ajax, and Pseudargiolus butterflies, because they have a spring form different from the forms of a later season. The result proved the possibility of producing in all three species the spring form, or something like it. Mr. Edwards suggests that the chrysalids producing such specimens in nature may have been subjected to such extreme cold over a long period as would be produced by a snow or ice envelope. Mr. Edwards has also discussed the melanism of the Turnus butterfly. He notices that the dark form of the female is restricted to districts where a summer generation is possible, and is thus inclined to think the cause of its original appearance "in some way climatal," and brings forward some evidence against Dr. A. Weismann's theory that the dark female has superior attractions for the male. He would further explain the probable greater abundance of dark forms in the West than in the South, by the larger proportion of insectivorous birds in the prairie region, and the association of this butterfly with a larger number of yellow-colored swallow-tails in the South.

Baron Osten Sacken has given an important paper on the distribution of Diptera in this country. He contends for the essential unity of the entire western region of this continent, from the eastern limit of the dry plains to the Pacific Ocean—a region characterized by its extreme dryness in summer. The general distinction between the western and eastern half of this continent, and the resemblance of the insect fauna of the former to that of Europe, is shown by the citation of a large number of important genera which do not occur in eastern America, but are found in both the other regions.

Mr. Scudder himself has given an analytical comparison of the butterfly faunas of eastern North America and of Europe, and has shown the greater richness of the European fauna, and has pointed out some curious disparities in the proportions of the numbers of members belonging to different groups. Europe proves to be peculiar for its wealth in brush-footed butterflies, America in skippers; and this difference is largely due to the fact that there are more than four times as many Satyrids in Europe as in America, and five times as many small skippers in America as in Europe.

Dr. Packard has made us acquainted with a new cave fauna at the southern extremity of Great Salt Lake, nearly as characteristic as that found in the caverns of Kentucky, Indiana, and Virginia.

A proper analysis of all that has been done in the field of biological investigations of injurious insects is difficult, for over three hundred octavo pages have appeared on the destructive locust alone, without counting Mr. Riley's book of two hundred and thirty-one pages.

With the exception of Mr. A. R. Grote's account of a species of Nephopteryx which injures pine trees by boring into the bark and wood and thus causing an exudation of the pitch, all papers which pretend to offer anything new upon injurious insects, other than the locust, were written by the members of the U. S. Entomological Commission.

Articles upon the destructive locust have appeared during the year from Messrs. Riley, Packard, Thomas, Dawson, Whitman, Phillips, Gaumer, and Godfrey. By far the most important of these, however, were by Messrs. Riley and

Packard. The former, in his ninth Missouri report, adds to our previous knowledge of the history of Caloptenus an account of the method by which the young escape from the egg, reports additional parasites, and gives the result of some valuable experiments upon the vitality of the eggs. He subjected the eggs to alternate freezing and thawing, to different degrees of moisture, to the open air, and to burial at various depths. By his experiments it appears that neither moisture nor sudden alternations of freezing and thawing have much injurious effect upon the eggs, that simple frost is actually beneficial, but that exposure to the free air is decidedly injurious; so that thorough harrowing will prove an effectual means of destruction. Mr. Riley also gives a very full history of the locust in 1876.

Dr. Packard gives a similar history for 1876 and general histories of the ravages of the locust in Colorado and Utah. In connection with the theory of their enfeeblement in moist regions, he gives some curious experiments, made by Prof. Samuel Aughey, on the comparative strength of the hind legs of individuals from Nebraska and Utah, clearly to the advantage of the natives of the latter State. He also discusses the relation of their migrations to meteorological phenomena, and publishes some interesting tables furnished for the purpose by the Weather Bureau. He adds interesting notes on the habits of the locust, and describes the insects from life, at every stage, and shows that it has three larval and two pupal stages.

A FATHERLESS AND MOTHERLESS RACE.

A STRANGE INSECT—THE BASKET CARRIER, OR HOUSE-BUILDER CATERPILLAR.

By WILLIAM H. GIBSON, New York.

ABOUT twelve years ago I discovered hanging from the branches of some larch or bald cypress trees in front of my house in Brooklyn some queer little drooping cases or cocoons. It was in the winter time and the trees were thinly clothed with foliage, disclosing immense numbers of the cocoons which had previously escaped my eye. I am an enthusiast on all subjects of natural history, and at that time, although only a boy of fifteen years, I was a continual student of the subject of insects, and these little cocoons exciting my curiosity and being easily accessible, I eagerly gathered a large number of them. I placed them in a box and began anxiously to look forward to the coming spring, when the little moths would appear from the cases and furnish another addition to my collection. The cocoons were about an inch and a half or two inches long, of a gray color, and were covered with little sticks or stiff leaves of the larch, arranged lengthwise up and down. Each was suspended to a small branch of the tree by a silken loop possessing considerable strength. My first impulse was to open one of the cocoons to see the "chrysalis." I took a pair of scissors and cut up the entire length of the side of one of the cocoons. It disclosed a quantity of loose floss silk and a cavity, but no chrysalis! and the only indication of the existence of its former inhabitant was a little speck of dried up skin, with the shell of a caterpillar's head attached. This struck me as very strange, and led me to make another trial. The second resulted like the first, the third ditto, and my countenance fell. I know it did, for I felt a keen disappointment after all my enthusiasm over the pretty moths I was going to get from them. With a determination to "go through the whole pile," I proceeded to open the fourth, and during the process I felt something hard in the interior. There was a sense of relief that I shall never forget as I carefully pulled open the fissure and beheld a shiny brown chrysalis within. It was easily coaxed out with a little shaking, and then came a second disappointment.

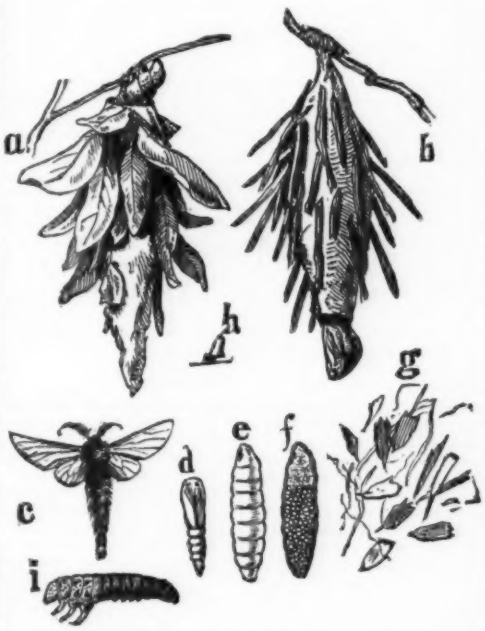
I remember how I was puzzled at the appearance of this queer chrysalis. On close examination it appeared more like a hard shelled caterpillar than a pupa. The usual formations observable in ordinary chrysalids, of semblances of legs, wings, etc., folded about the body, were utterly wanting in the object before me, and it appeared merely like segment after segment of body from one end to the other, and what I supposed was the head extremity seemed furnished with about six little dried up prolegs like those of a caterpillar. On touching this extremity it seemed to crackle, and on breaking off a little piece of the shell I observed some yellow fuzz in the interior. Ah! perhaps the moth is inside, I thought, and with great care I made a larger opening—fuzz! more fuzz!! and fuzz!!! was all that rewarded my investigations, and I came to the conclusion that the moth must have escaped and left all of his feathers behind. Determined to empty the case and see, I blew sharply into the opening. The air was filled with the powdery feathers which were thus expelled, and a still further examination of the shell disclosed—what next? There certainly was something in there! It evidently was not a moth. I eagerly broke the casement. Another surprise! Two-thirds of the entire length of the shell was packed full of—nothing but *eggs!* in a solid mass. I remember cherishing a sense of pity for such an outlandish kind of creature as this seemed to be. "Some of the caterpillars stayed in their warm homes in the hot summer weather and left them empty for some mysterious reason in the winter; while others concluded to remain and content themselves with the ignominious fate of turning into a mass of eggs and fuzz!" Thus I soliloquized; and after satisfying myself that the entire lot of cocoons were either utterly "bankrupt" or else mere "egg baskets," I put them away with the thought that scientific investigation in this branch at all events was a "dismal failure."

On turning the matter over in my mind I concluded to study the thing further. I procured more of the cocoons and placed them in a box. The question now was, will those miserable eggs hatch? and if so, what manner of beast will come out of them? I was prepared for anything. If they had taken root and sprouted into larch trees I don't know as I would have been much surprised. I kept them, and in the following June, on paying a visit to the box, I was confronted with a most singular and laughable spectacle. This, then, was the progeny of these egg-chrysalids! All over the cover and sides of the box, the mantelpiece on which it rested, the walls and ceiling, dangling in festoons from different parts of the same, were thousands and thousands of little party-colored animated specks—now rolling over on the cover of the box, now standing upright, and again twisting and dangling from a microscopic web, wriggling and turning all sorts of queer antics in utter confusion. It was the strangest sight I ever beheld, and as quick as my surprise was over I essayed a closer acquaintance. The small specks consisted of little cases or baskets the eighth part of an inch in length, each of which was occupied by a lively little tenant, which on being pulled out of his house showed himself to be a tiny black caterpillar, with a very intellectual head, this portion being about a third of the size of the entire creature. The interior of the box was literally alive with the little fellows, and as I examined more closely I noticed a marked difference in the color of their various diminutive cases. Some were pure white, others were buff colored; some were party-colored, and one was red, white, and blue. This little individual appealed to my patriotic sentiment, and I took him to the window to get a closer look at his domicile.

Until this moment it had not occurred to me to examine into the material of their tiny baskets. I went back to the box. I had previously noticed a mottled appearance in its interior, but it had not particularly interested me. It now became a matter of more significance. The box was made of common straw board covered with white paper, and at its upper edge, inside, there were attached two loose pieces of blue paper, which formerly covered the articles packed in the interior. The white paper had been worn through by the myriad pairs of little teeth, and with the fiber thus obtained, and by the aid of the silk web of which the caterpillars seemed to have an inexhaustible supply, the countless numbers of baskets had been made. The mottled effect in the interior of the box was caused by the yellow straw board appearing in spots where the outer paper had been gnawed away.

This yellow board had again been utilized by several of the caterpillars who preferred more highly colored houses, and the blue paper was riddled with holes by the immense demand made upon it for building material. Near by, on the mantel, there was a pile of books; notable among them was an old leather covered volume long since past its better days. It was an old account book, and from its worn pages there protruded the end of an aged red blotter. The soft yielding nature of the paper made it very popular among the little architects, and many of them sported conspicuously gaudy apartments. It was from this blotting paper that the patriotic specimen above alluded to obtained the red material, the white and the blue portion having been built in the interior of the box. The buff color of the leather had been also largely employed, as well as some green worsted from a little mat on which the books were resting. Altogether it made a most amusing spectacle, and it is one which I have since enjoyed many times.

My next course was to transport the tiny creatures to the larch tree, where they could obtain their food. I did so with a determination to watch them in progress of growth.



THE BASKET CARRIER CATERPILLAR.

And my observation was rewarded. As the caterpillar increased in size, he widened the open end of his case, and ornamented its exterior with bits of sticks. At first it was light in proportion to his strength, and he traveled around with it in an upright position, using his six prolegs only in locomotion. As he increased in size he was satisfied to drag it along after him, and when alarmed he would draw the opening firmly up against the branch upon which he was crawling, and thus completely close the case.

I watched the caterpillars closely until the autumn, at which time they were full grown. They were brownish in color, an inch in length, smooth, and were provided with minute hooks at the extremity of the body, which afforded a firm grasp of the silky lining of the case. The caterpillar never leaves the case, and will often submit to being pulled asunder before loosening its hold on the interior.

As the full growth of the caterpillars approached I became enthusiastic.

There was a problem to solve, and I had set my heart on solving it. These insects were *true caterpillars*, unless I was woefully misled by my authorities on the subject. And if they *were* caterpillars, there must be a transformation into some species of perfect lepidopterous insect.

I remembered the empty cases of the winter previous, and in order to solve *that* mystery I watched the cocoons until the caterpillars were full grown, and then captured a hundred or more, each with its occupant. I placed them in a box. They crawled about for a few days, and finally closed up the opening of the cocoons and all was quiet. Occasionally I would open one of the cases, only to find the caterpillar in a hunched up state of indolence, till at length I discovered a chrysalis, a *true* chrysalis, with all the markings of the wings and legs, etc. It was long and slender, and very lively. I put it back in its case, closed the box and waited for developments. In about three weeks' time, more or less, I went to the box one morning, and was greeted with a buzzing noise; no sooner was the cover lifted than out flew—a beautiful butterfly? Oh no!—a miserable little black thing, that went buzzing around, seeming to have no greater ambition in life than to go bumping his head against everything in his reach. I remember the sense of disgust which crept over me at the result of all my careful research. I had looked for a butterfly glowing with all the colors of the rainbow. It was to have a grand central point in my collection, and I had lain awake nights thinking about it. And now the chrysalis from which I had such exalted hopes had given birth to a miserable little "fly bug." I struck the "buzzing bumper" with a towel, and took a look at him—yes, he really was a *moth* after all, but he looked more like a *fly* or fuzzy bee. His body was remarkably long and slender, and he was wonderfully lively with his tail. His wings were perfectly transparent, like those of a fly, and his head was decorated with two pretty feathered antennæ. I pinched him "under the fifth rib" and stuck a pin through his thorax, and went back to the box. Here I found one or two more of the moths clinging to the paper inside, and my attention was attracted to many of the cocoons by the appearance of a chrysalis protruding from the opening. This then explained the "empty cases" of the year previous. Just before the moth escapes this chrysalis works its way through the lower end of the cocoon, and afterward falls out altogether.

I had collected them in this condition. Several of the moths appeared afterward, all alike, and all males. In vain did I watch for a female, and in vain *have I watched for a female specimen of this moth in the many years which have since elapsed.*

For twelve successive years I have carefully studied this curious insect. I have collected hundreds of the caterpillars and cocoons. I have watched the caterpillars from the egg to the full growth, and have kept the cocoons winter after winter with the above result. I have ransacked libraries in the hope of finding some information on the subject from a reliable authority, but to no purpose, those accounts which are given *seeming utterly to ignore the singular features of the reproduction of the insects and fertilization of the eggs.*

Harris' "Insects Injurious to Vegetation," of a copy of which I was the happy recipient about the time of my discovery of these cocoons, thus speaks of an insect which is closely allied to the foregoing:

"The moths, of which there are several kinds produced by the sack-bearing caterpillar, differ very much from each other, but as they all agree in their habits and general appearance while in the caterpillar form, they are brought together in one family called *Psychadæ*, the Psychians, from Psyche, a genus belonging to it. The Germans give these insects a more characteristic name, that of *Sackträger*, that is, sack bearer, and Hübner called them *Canephoræ*, or basket carriers, because the cases of some of them are made of little sticks somewhat like a wicker basket.

"The cases of the insects belonging to the European genus Psyche are covered with small leaves, bits of grass or of sticks placed lengthwise on them. The chrysalis of the male Psyche pushes itself half way out of the case when about to set for the moth; *the female never leaves its cocoon*, is not provided with wings, and its antennæ and legs are very short.

"* * * The cases of *Oiketicus*, another and much larger kind of sack bearer, inhabiting the West Indies and South America, are covered with pieces of leaves and of sticks, arranged either longitudinally or transversely. The cases of some of the females measure four or five inches in length. Some which I received from Cuba were covered with little bits of sticks about a quarter of an inch long, arranged transversely, and the cases were hung by a thick silken loop or ring to a twig; the lower end of these cases was filled with a large quantity of loose and very soft brownish floss silk, which completely closed the orifice within. * * * The female has neither wings, antennæ nor legs, and *is said to remain always within its cocoon*. Some years ago a case or cocoon of an Oiketicus, which was found on Long Island, was presented to me. It was smaller than the West Indian specimens, measuring only an inch and a half without its loop, and was covered with a few little sticks longitudinally arranged. *It contained a female chrysalis*, with the remains of a caterpillar. In Philadelphia and the vicinity cases of a similar kind are very common on many of the trees, particularly on the arbor vitæ, larch and hemlock, which are often very much injured by the insects inhabiting them. These are there popularly called drop worms and basket worms."

This last mentioned variety is evidently the identical species which was the subject of my investigations, and I would call the reader's attention to the phrase, "*It contained a female chrysalis.*" Doubtless Mr. Harris broke open the shell and found the eggs, which I have described. He describes no female *moth*. In the instance of the European species he describes a female that "never leaves its cocoon," and in the Oiketicus of the West Indies "*the female has neither wings, antennæ nor legs, and is said to remain always within its cocoon.*"

This West Indian species is further described in "Wood's Natural History:"

"As soon as the larva is hatched from the egg it sets to work building its habitation, and even before it begins to feed, this industrious insect begins to work. When the creature is small and the house of no great weight, it is carried nearly upright, but when it attains size and consequent weight it lies flat and is dragged along in that attitude. The entrance to this curious habitation is so made that the sides can be drawn together, and whenever the creature feels alarmed it pulls its cords and so secures itself from foes.

"In this domicile the transformations take place and from its aperture the male insect emerges when it has assumed its perfect form, and takes to flight. But the female behaves in a very different manner. According to the ancient maxim she stays at home and takes care of her house, from which she never emerges, nor indeed can she emerge, as she has no external vestige of wings, and looks more like a grub than a moth, the head, thorax and abdomen being hardly distinguishable from each other. Love and courtship with this insect are carried on quite in an oriental fashion, pushed to extremes; for whereas the Oriental in many cases never sees the face of his vailed bride until after the nuptial ceremony is completed, *the house-builder moth never sees his mate either before or after marriage*, and so is obliged to love blindly or not at all."

Thus Mr. Wood, in his usual charming manner, describes an insect closely allied to the American variety, but he generalizes on the one topic of interest to such an extent as to render his remarks of little value from a scientific point of view, even in *this* species.

A. S. Packard's "Guide to Insects" is more specific, but nevertheless unsatisfactory. In speaking of the American species, he says:

"The male of the basket worm is stout-bodied, with broad pectinated antennæ and a long abdomen, *the anal forceps being capable of unusual extension in order to reach the oviduct of the female, which is wingless, cylindrical, and in general form closely resembles its larva, and does not leave its case.* On being hatched from the eggs, *which are, so far as known by us, not extruded from its case by the parent*, the young larvæ immediately build little elongated basket-like cases

of bits of twigs of the cedar on which they feed, and may then be seen walking about, tail in the air—this tail, or abdomen, covered by the incipient case and presenting a comical sight. The case of the full grown larva is elongated, ova., cylindrical, and the fleshy larva transforms within it, while it shelters the female through life."

The reader will remember my allusion to the extenuated flexible tail of this moth. It attracted my *attention*, but never in *any* way has it tended to settle the problem of the fertilization of the eggs, and from the standpoint of my own observations I should pronounce the assertion above from Packard's work, as a mere *mental deduction* on the author's part, and not the result of actual notice. He admits that the "eggs are not extruded from the case," and must know, if he has carefully studied the insect that the case is quite tightly closed.

In bringing my remarks to a close after giving the various authorities, I am now prepared to assert, as the result of my own personal investigations through a period of twelve years, that the male moth not only "never sees his mate either before or after marriage," as Mr. Wood remarks, in relation to the other species, but that in the *American species* the marriage *never takes place at all;* that the male *never knows of the existence of his mate*, and, in conclusion, *that there is no mate*, unless an inanimate bundle of eggs can be so considered.

These eggs of course fulfill the office of the female in the reproduction of the species, and in regard to the manner of their fertilization it is a mystery explainable only on two theories. The male moth I leave out of the question altogether. I am satisfied that *his intervention is not necessary*.

Firstly. Either the fecundation is passed down through several generations after the manner of the Aphides, or—

Secondly. It takes place during the caterpillar state.

The latter is not probable, as there is no similar case known, and, indeed, is refuted by my own experiments, at least so far as the last half of the caterpillar's life is concerned.

I have tried every conceivable test before coming to the above conclusions, but I am now satisfied with the result.

I have taken one cocoon in the caterpillar state and placed it *by itself* in a box. The caterpillar has there transformed to a female chrysalis, and the eggs of the same have hatched in the following spring. The nearest semblance to a female moth that I *have ever discovered* has been the "fuzz" which is contained in the end of the chrysalis shell, which under the microscope reveals forms of wing scales similar to those on ordinary moths.

The description of the female given by Packard—"Wingless, cylindrical, and in general form closely resembling its larva"—is all *presumptive* from *my* point of view, and is not written from a fullness of knowledge.

I would add that I am already aware of the existence of one species of "Psyche," building a spiral case similar to the Helix, which has been known and is, I believe, acknowledged by naturalists to have produced caterpillars from eggs which have never been fertilized by the male.

The same phenomenon has never been admitted with reference to the species which forms the subject of this communication. A fatherless and motherless race so far as I can discover.

I have for some time been intending to make public the result of my investigations on this curious insect. I have now done so, and any further information on the subject will be thankfully received.

THE ENEMIES OF BOOKS.

THEIR NATURAL HISTORY—THEIR RAVAGES—THE METHODS OF DESTROYING THEM.

We remember the case of a negro who, during the days of slavery, having escaped to the North, obstinately refused all offers that were made to teach him to read, basing his objections to such an acquirement on a circumstance that had come under his observation during the period of his servitude. It appears that a fellow slave, who was a most excellent and industrious tailor, having by stealth learned the forbidden art of reading, found his newly acquired accomplishment so fascinating that he thereafter eagerly devoured the contents of every book or paper that fell in his way, neglected his trade, and hence became, of course, a "poor, miserable, shiftless fellow!" The opinion of our freedman,

Fig. 1. COCKROACH.
(*Blatta Americana.*)

therefore, having been determined by this striking example of the evil effects of educating the masses, he very properly, in his own estimation, refused to allow himself to be made a party to the further spread of knowledge, "book-learning," from his standpoint, being the prime cause of all the poverty and wretchedness in the world. Now this man was but the type of an immense army of book-enemies, which has existed from the earliest periods of history, and which will probably never be exterminated. It is to hordes of such men, urged on by the ignorance or caprices of unscrupulous leaders, that we owe the destruction of some of the largest and most valuable libraries of antiquity. But it is not our intention in this article to discuss the natural history of *this* species of "book-enemies," but rather that of a host of other animals, which although physiologically inferior to the human book-enemy, are nevertheless fully his equal in the fearful depredations that they commit when they once obtain access to our books or manuscripts.

It is a popular notion that rats and mice are the chief culprits in book destruction. Their case is certainly a bad one, and we would scarcely know how to outline a defense in their behalf. What share these inveterate gnawers had in the destruction of the parchment rolls that contained the now lost works of Varro, Terence, Livy, and other writers of antiquity, or how many valuable missals they have disposed of by eating the parchment for the sake of the animal matter it contained, will never be known.

But certain it is that the art of printing has provided these destructive rodents with a field of operations of an extent that was never known in antiquity, nor in those ages when the use of paper was almost ignored; and, with a complete

Fig. 2. PERTINACIOUS DEATH-WATCH.
(*Anobium Pertinax.*)

change of materials in book-making, has come an entire change in the *motives* of rats and mice for destroying them. It is not the case now, as it was formerly, that these animals cause such irreparable damages to our most valued literary works for the sake of food, since a diet of paper would scarcely prove very fattening; but they gnaw away the leaves and covers of our choicest volumes, and convert our most beautiful manuscripts (by nibbling at them with their sharp chisel-shaped teeth) into a soft flocculent mass, solely for the purpose of providing a downy couch for their expected offspring. It is an easy matter, comparatively, to guard against the incursions of this species of enemy, their very size offering us one means of protection; we will therefore turn our attention to a class of book-enemies very much more to be dreaded, not only on account of their infinitely smaller size, but the facility with which they are enabled to hide in unexpected places, and quietly go on with their work of destruction. We find these minute pests in the extensive domain of entomology.

To begin, we will direct attention to the extensive ravages

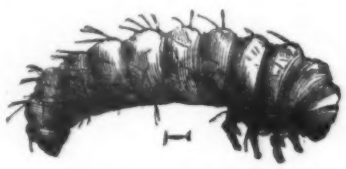


Fig. 3. LARVA OF PERTINACIOUS DEATH-WATCH.
(Very highly magnified.)

committed by the family of *Blattarians*, or cockroaches, on the libraries of Africa and the New World. How many precious archives in the Colonies of France and England, and how many books of inestimable price in Brazil, Peru, and in the old empire of Montezuma, have been devoured by that disgusting insect known as the "American Cockroach" (*Blatta Americana*, Fig. 1) it is impossible to estimate. D'Orbigny, who was so well acquainted with this detestable family of insects, after having enumerated the almost incredible number of cockroaches that infest the world, expresses himself thus: "The cockroaches are in general nocturnal insects of great agility and run with great swiftness. They exhale an odor of the most disgusting nature, which sticks to any object with which they have come in contact. They attack all animal and vegetable substances, in whatever state these may be found. It is principally in warm countries that they commit the worst ravages. It is

Fig. 4. LARVA OF STRIPED DEATH-WATCH.
(*Anobium Striatum*.) (Magnified.)

said that they are able to pierce through a trunk or a chest; and, besides, their flat shape permits them to introduce themselves through all sorts of chinks and crevices. * * * Entire barrels of edible substances often fall a prey to their voracity, and in a short time are found swarming with these insects." Now as far as "barrels of edibles" are concerned, their contents may be replaced; but not so with the precious contents of books which once destroyed are often lost forever—especially if, as often happens, the volumes be unique. Even the work of the ablest binder counts for nothing in the presence of this loathsome insect. That charming old traveler of the sixteenth century, Jean de Léry, recounts, in his picturesque style, how one fine day his boots, as black as they were, became entirely white through the gnawing of these vermin. Indeed, the most valuable volumes, embel-

Fig. 5. LARVA OF *PTINUS MOLLIS*.
(Magnified.)

lished with the richest products of art, would be just as likely to meet the fate that Jean de Léry's boots did, were no precaution taken to put them out of the reach of the omnivorous cockroach. We have seen very handsome book-bindings greatly disfigured by a single night's depredations of this insect.

There is a French aphorism which says that "a book with a puncture is a book dishonored;" and certainly no real lover of books will deny the truth of it. How disheartening it must be, then, for a genuine bibliophilist to take down a choice edition of some old author from the shelves of his library, where it has lain undisturbed for some time, only to find its pages disfigured by the ravages of an insect larva. It is true that the novelist, Charles Nodier, has said that "*the library of an industrious scholar is never attacked by worms;*" but then it must be remembered that even the hardest working student will have in his collection some books, at least, that scarcely ever demand consultation. Among the insects that prey upon books there is none more dreaded by the librarian than the little beetle whose mis-

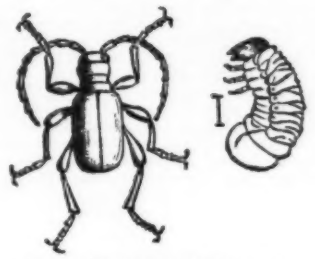


Fig. 6. *PTINUS FUR* AND LARVA.
(Magnified.)

deeds we shall chronicle through a quotation from a celebrated entomologist, who has been a faithful observer of its habits. "Have you never," says he, "remarked in libraries where books are allowed to slumber, in archives where old registers are looked over only at rare intervals, have you never remarked, I say, those deep sinuous erosions which usually involve a large number of leaves, and sometimes put an entire volume, or a bundle of papers, in a state of mere shreds? Have you never carefully examined these furrows, and perceived in them a short, thick grub, bent like a hook? Well, that grub is the first stage of a little beetle called the 'Death Watch' (*Anobium*), which, if it were allowed to do so, would destroy a whole library as surely as Julius Cæsar destroyed that at Alexandria; only, of course, it would take it a longer time."

There are many species of these very small beetles, and they all work terrible havoc among furniture, which, when filled with the holes made by their larvæ, are popularly termed "worm-eaten." They are not in the least particular about their diet, and will devour anything of a vegetable

Fig. 7. WEEVIL.
(*Bruchus.*) (Magnified.)

nature. Of the species represented at Fig. 2, Linnæus said, "it bored into and destroyed my chairs" ("*terebrarit et destruxit sedilia mea*"). The larvæ are called "book-worms" when they attack books. Old books and those seldom used are often found bored through by them. The larvæ of several species (*Anobium pertinax*, Figs. 2 and 3; *A. hirtum*; *A. striatum*, Fig. 4, and *A. paniceum*) are known to ruin books. Kirby and Spence mention a case where twenty-seven folio volumes were eaten through, in a straight line, by a larva of one of the species (probably *A. pertinax*, Fig. 3), in such a manner that by passing a string through the perfectly round hole the twenty-seven volumes could be raised at once. One species (*A. paniceum*) has done great damage in the Cambridge Library to the valuable Arabic MSS. brought from Cairo by Burckhardt. These beetles ob-

Fig. 8. COMMON TABBY MOTH.
(*Aglossa Pinguinalis.*) (Natural Size.)

tain their common name of "death watches" from their habit of striking their head against the wood on which they are standing at the pairing season, thus producing a ticking noise, which is regarded with great dread by the superstitious, and is supposed by them to forebode a death in the household.

Allied to *Anobium* are certain small beetles, belonging to the genus *Ptinus*, two species of which (*P. molle* and *P. fur*) prove like the former quite destructive to books. Nothing, however, of a vegetable nature comes amiss to them—planks, rafters, beams, chairs, and tables, as well as books, all fall a prey to the hungry industry of their larvæ; and they bore through all such articles holes as sharply cut as if

Fig. 9. COPPERY TABBY MOTH.
(*Aglossa Cuprealis.*) (Natural size.)

they had been drilled with the finest instruments. *Ptinus fur* is the most widely diffused species, and is often found in our museums destroying collections of insects, etc. It is about one-sixth of an inch long, and of a uniform chestnut-brown color. In Fig. 6 it is represented in outline, enlarged, as well as the figure of its larva.

After the Ptinidæ, the Bruchians, or "Weevils," are said to be among the most industrious of book-enemies. These insects in their winged state are hard shelled, and distin-

guished from other beetles in having the forepart of the head prolonged into a long and slender snout, in the end of which the mouth opening and the small horny jaws are placed. This snout (which in the Bruchians is folded over on the chest) they make use of not only in feeding, but in boring holes, into which they afterward drop their eggs. The history of many American species is imperfectly known, if we are to credit a recent French periodical; however, our American "Pea-bug" (Fig. 7), which has now spread over Europe, has become an active colaborer of the "Death Watches" in boring holes through the pages of European books, to deposit the eggs that produce the destructive larvæ. According to Kirby and Spence, a minute beetle, to which they give no common name, but merely a scientific one (*Hypothenemus eruditus*) out of all proportion to the size of the insect, is often found burrowing in considerable numbers in the bindings of books and doing much damage.

The larva of the common "Tabby Moth" (*Aglossa pinguinalis*, Fig. 8) will often establish itself upon the binding of a book, and spinning a robe, cover it over with its own excrement, thus doing the volume no little injury. Dr. Packard states, on the authority of Prof. A. E. Verrill, that the larva of another species (*Aglossa cuprealis*, Fig. 9) does great damage to the old leather bound volumes in the library of Yale

FIG. 10. SUGAR LOUSE.
(*Lepisma.*) (Enlarged.)

College, by eating out great patches and galleries in the leather covers, and also, in some cases, some of the glue and pasteboard.

Perhaps the most destructive of insects are the white ants of the tropics, which devour everything except glass and metals that comes in their way. Humboldt states that in equinoctial America, where these and other destructive insects abound, it is rare to find books or papers that go back more than fifty or sixty years. Fortunately, these little animals have never as yet emigrated from their native shores. Kirby and Spence state that a little insect belonging to that microscopic family, the *Acarini*, or "Mites," eats the paste that fastens the paper to the bindings of books, and so loosens it. The name of this insect is *Oheyletus eruditus*, or, as we might translate it, the "Erudite Mite." In the almost limitless class of insects there is one small but interesting family in particular, containing minute, wingless forms, which seem to connect the true winged insects with the Myriapods. These agile creatures, called "Bristle-tails," have a long flattened body, with metallic scales, in form somewhat like those of butterflies; and these scales are a favorite

FIG. 11. BRAZILIAN TRAÇA.
(Magnified.)

object with all microscopists as "tests." One species, the "Sugar Louse" (*Lepisma saccharina*), is very common in almost every house, where it eats holes in silks and silken tapestry, and devours the paste and eats holes in the leaves of books. It has a spindle-shaped body (Fig. 10), covered with silvery scales, the sides of the abdomen being furnished with a series of appendages, or false feet, and the tail provided with three bristles pointing outward. Judging from an engraving and description, merely, of the insect, we should say that the Brazilian "Traça" (Fig. 11) was closely related to our *Lepisma*. The eminent French philologist, Villoison, who was sent by his government to Venice in 1778, in order to search the library of St. Mark for unpublished Greek manuscripts, and who subsequently traveled several years in Greece and the Archipelago, mourns, in his work entitled *Fragments sur la Grèce*, over the fact that he found the libraries in the monasteries at Salonica, Scio, Santornin, Naxos, and even at Constantinople falling literally into dust through the ravages of insects. But however great be the voracity of the insects that have devoured so many precious volumes in the country of Homer, it can scarcely equal, judging from the accounts that we have of it, that of the minute "Traças" above mentioned. These almost imperceptible insects give abundant proof of the activity of their appetites in the curious figures which they trace across the most precious pages of text, converting them in a few days into real lacework, and destroying all semblance of printing to such a degree as to render the pages undecipherable to the most persevering student. It is to these Traças, rather than to handling by students, that is due the destruction of those vocabularies which made known in the sixteenth and seventeenth centuries the elements of the Indian languages; it is to these insects, as much as to the dampness of the old repositories in which they were stored, that is due the disappearance of the records which narrated the deeds of the old *conquistadores*, or the stories of intrepid voyagers. Happily some of these old records were copied in former centuries, and the copies taken to Europe. M. Franklin Ramiz Galvam, at present director of the rich national library of Rio de Janeiro, has given a sad description of the difficulties by which the studies of South American savants are beset, through the ravages of the Traça—an insect that he has not been able to destroy. Having enumerated the evils, let us cite such remedies as we know. Unfortunately we no longer possess a knowledge of those heroic methods of treating noxious insects which the old naturalist, Moufet, loves to tell about, while he instances the fact that the garments of Servius Tullius still remained intact from the incursions of moths after more than five hundred years. The *Bulletin of the Bibliopholist* says that "it is an indisputable fact that the odor of Russia leather is so disagreeable to all insects that naturalists have given a beautiful beetle called the *Trichius* (which possesses this odor to a high degree) the surname of *eremicola*, because other species carefully avoid it. We have had the pleasure of preserving our books, and have attributed it to the care we

FIG. 12. LARVA OF TRAÇA.
(Highly magnified.)

have taken to keep some of these insects among them as much as possible. A large American *Trichius* (*T. scaber*), often met with, has this same powerful odor of Russia leather to such a degree that its presence may be detected by the scent alone at a distance of two or three yards from its retreat.

Unhappily the numerous insects which are continually feeding on our literary treasures do not all disappear under the influence of *Trichius eremicola*, and there is even some doubt about the efficacy of Russia leather itself, the odor of which it so powerfully exhales. Several insects make their primitive cradle in the paste and glue used by the binder; and from these it is difficult to dislodge the enemy. Many means have been proposed for preventing them from obtaining a lodging in such places; such as mixing alum, colocynth, arsenic, or corrosive sublimate with the paste before using. The learned Namur recommends against such beetles as the "Death Watches" and "Weevils" frequent fumigations of sulphur. But this while killing the perfect beetle has, of course, no effect on their eggs. The perfect insects as well as their larvæ may always be speedily killed when discovered by the application of a little chloroform; and that, too, without any injury to the book. The most efficacious means, however, of preserving a library where there is a large collection of books is to look them all over quite frequently and beat them out.

THE EARTHQUAKES OF 1877.

PROF. C. W. C. FUCHS states that during 1877 five important eruptions of different volcanoes took place. The eruption of the South American volcano Cotopaxi, which lasted from June 25 to 28, was of a most characteristic nature for this mountain. According to the phenomena by which it was accompanied, it must be designated as an eruption of ashes and mud. Although Alexander von Humboldt's view, that the South American volcanoes do not produce lava, has been refuted long ago (Cotopaxi sent forth a copious stream of lava in 1853), yet the most frequent eruptions from this mountain are those of ashes only, without a flow of lava. Streams of mud are often combined with eruptions of this kind, and have different causes; in 1877 they particularly devastated the valleys of Chila and of Tumbaco, and in the former many hundreds of lives were lost through them. The ashes which the volcanoes ejected so filled the air that complete darkness reigned everywhere, and the dust was so fine that it entered even into the interior of houses, although the doors and windows were shut.

The most violent eruption of 1877 occurred upon the island of Hawaii. Twice interrupted, the lava forced its way to the surface in three different places, and thus furnished the most undeniable proof that one and the same bed or hearth of lava may produce eruptions in any of the numerous craters of Hawaii, according to time and circumstances. The first part of the eruption occurred on February 14 from a little side crater close to the summit of Mauna Loa; its duration was six hours, and the height of the column of smoke, which assumed the shape of an Italian pine-tree, was estimated at 5,000 meters. The second part occurred on February 24, in the Bay of Kalukeakua, well known as the place in which Cook, the great discoverer of the Sandwich Islands, was assassinated. This eruption was submarine, and lasted two days; its seat was in the middle of the bay, which is surrounded by numerous prehistoric records of its volcanic nature. On May 4 the lava found its usual way to the surface through the lava lake of Kilauea, which has solidified for some time. Here the wonderful phenomenon of high jets of lava occurred, a phenomenon which is peculiar to this spot only. During a period of six hours, now here, now there, vast jets of liquid lava rose from the ground, and their number was so great that at one time more than fifty simultaneous ones were counted, some reaching an altitude of thirty meters.

The third eruption was that of the small Japanese island-volcano, Ooshima, and lasted from January 4 to February 6 or 7. Violent subterranean noise and disastrous earthquakes accompanied the volcanic phenomena, particularly on January 20 and on February 4 and 5.

On June 11 an eruption occurred in a volcanic district almost unknown hitherto, viz., near the Colorado River in Southern California, at some sixty miles' distance from Fort Yuma. The last eruption was a submarine one, and happened on June 15, near the Peruvian coast.

The number of earthquakes during 1877, of which Prof. Fuchs was able to obtain reliable accounts, amounts to 109, and he remarks that this is very nearly the average number per year, if compared to his annual compilations, which now extend over a period of thirteen years. They were distributed over the seasons of the year as follows:

December, January, February	33 earthquakes.
March, April, May	31 "
June, July, August	11 "
September, October, November	34 "

On fifteen days several earthquakes occurred simultaneously in different places. Certain districts, such as Peru, Bolivia, Tokio (Japan), the Island of Ooshima, Hawaii, etc., were visited by real earthquake periods, consisting of a large number of more or less violent shocks and detonations, while in others several earthquakes, separated by long periods of tranquillity, were observed. Among the latter we note

Sudenburg (Styria): January 4, December 27 and 28.
Western Odenwald: January 2 and 10.
Wald (Styria). January 12 September 5.
Rattenberg (Tyrol . April 8, October 11.
Bad Tüffer (Styria) April 4, 7, 24, 25, September 12.
Callao: April 22, May 14, October 9.
Western Switzerland: May 2, October 8, November 30.
Lisbon: November 1 and 4, December 22.

The earthquakes in Switzerland spread over a very considerable area. The first shocks on May 2 began near the Lake of Zürich and proceeded in three directions, viz., as far as Glarus and St. Gallen in the east, Mühlhausen in Alsace in the west, and the Black Forest in the north. They were followed by others more violent, and even more widely spread, on October 8. These were felt most severely at Geneva, where many chimneys were thrown to the ground; but they were distinctly noticed in the whole canton of Geneva, as well as in the Vaud, the Valais, Neufchatel, Berne, Freiburg, and Basel, and also in the French departments of Drome, Isère, Rhone, Savois, Aix, Jura, Doubs, and even at Mühlhausen in Alsace. The extent of this earthquake toward the west was therefore a far more considerable one than toward the east, where the Alps seem to have hindered its progress; only in the broad Rhone Valley it was felt as far as Sitten. This is all the more remarkable since the Jura Mountains seem to have been without influence regarding its progress in the west. The greatest breadth of the area where the phenomenon was noticed, *i. e.*, from Lyons to Sitten, measures some 200 kilometers, while its greatest length, *i. e.*, from Valence to Mühlhausen, is 337 kilometers.

Another earthquake of large extension was the one felt on April 4 in the Eastern Alps; it was observed from Lower Styria as far as the junction of the Save with the Danube.

The most violent earthquake was the one which occurred on the South American coast on May 9, and in its whole course, as well as with regard to the minor phenomena which accompanied it, it can be compared only to the earthquake which occurred in the same region on August 13, 1868.

A VARIATION IN THE MOON'S MOTION CAUSED BY THE EARTH'S SPHEROIDAL FIGURE.

By D. P. BLACKSTONE, Berlin, Wisconsin.

SIMON NEWCOMB in his paper in the November number of the *Journal of Science and Art* admits that the lunar theory having occupied the attention of mathematicians and astronomers of every century for two thousand years is now incomplete. Mr. Newcomb is evidently entitled to much credit for the results he has obtained from his researches and his discussion of the observations of eclipses and occultations that occurred previous to 1750, extending back over a period of more than two thousand years. He has doubtless proven to the satisfaction of astronomers that Hansen's empirical term, eight times the mean motion of Venus minus thirteen times that of the earth, adjusted to satisfy the lunar observations between 1750 and 1850, is a failure outside these limits, making a column of residual errors worse than that of pure theory.

Mr. Newcomb has given us in his paper a column of outstanding corrections to pure theory, having secular acceleration 8″·8, which he reconciles with observations from 1625 to 1875 by an empirical formula adjusted to the discrepancies between these limits. With this column of outstanding corrections I shall in this paper compare my column for the irregularity in the motion of the moon, due to the variation in the attractive force of the earth, caused by its spheroidal figure, and close up the gap between accepted pure theory and observation, with formulæ based on the law of gravitation.

The results of the pendulum experiments at places having latitudes from the equator to seventy-nine degrees fifty minutes, after due correction for centrifugal force and for distance from earth's center, are reconciled by my published formulæ to find the variation in gravity caused by the earth's spheroidal figure. Hence it is evident that my formulæ, admitting them to be truly empirical, must be accepted as reliable to be used in computing the length of the pendulum at any place on the earth's surface, or to find the variation in gravity due the earth's spheroidal figure, at least until a place can be found where the law does not hold true and not exceptionally explained.

My mathematical paper published in SUPPLEMENT No. 75, on "The Attractive Force of the Atom in Combination," develops formulæ to find the ratio of the attraction of the earth at any latitude and at any distance from center outside of surface, to the attraction of a sphere containing the same mass as the earth at the same distance. The above referred to paper with others I sent to three distinguished American mathematicians and astronomers, and received in reply: From first—"I have looked over your papers as far as my time will permit and have not noticed anything upon which I should differ from you." From second—"In the first step of your work you appear to make a mistake by making the component of a force proportional to the square of the cosine of its angle instead of simple cosine, which ought to be used." From the third—"I should say the course of reasoning you employ is not admissible. There seems to be some confusion in your mind as to the terms 'force' and 'power or work,' which you would do well to clear up. Force is by no means synonymous with work."

It is true in the first step of my work I made the component of a force proportional to the square of the cosine of its angle, which is accepted to be in accordance with the law of "power or work" for the rectangle, as I demonstrated in SUPPLEMENT No. 85. In the second step of my work I demonstrated that all the matter of the sphere can be represented on a certain arc of rotation or zone, B C D, by a certain amount of matter under such a condition that it will attract any outside atom, P, at any distance the same as the sphere. I applied this step of demonstration as though the representative matter on zone, B C D, was equal to all the matter of the sphere, which is true only when the attractive atom, P, is at an infinite distance. After receiving the second criticism I proved by clear demonstration, which I shall at some future time publish, that one of the two equal fac-

tors of cosine square in the first step of my work is due to the ratio, the whole matter of the sphere to its representative matter on zone, B C D. Of course such a demonstration nullifies the criticisms.

Taking the attractive force of a sphere of the same mass as the spheroid for the standard unit, computations from my integrated formulæ show that the difference in the attraction of the earth caused by figure varies very nearly as inverse square of distance. For an outside test of the validity of my investigation I have made three computations from the formula given in Newton's Principia, Book I., Prop. XCI., Cor. 2. I find in case of an oblate spheroid of uniform density, having polar to equatorial radius as 100 to 101, the attraction at the pole of the spheroid is to the attraction of a sphere at the surface, having radius 100 and same density as the spheroid, as 126·1 to 125·1; at one radius distance from pole or two from center, as 59·7 to 58·7; and at four radii distance from center, as 52·7 to 51·7. The solid contents of the oblate spheroid is to that of the sphere as 10,201 to 10,000. As the attraction of spheres at the same distance varies as mass, to find the ratio of the attraction of the spheroid to that of a sphere of same mass as spheroid, we must multiply in case first $\frac{126{\cdot}1}{125{\cdot}1}$ by $\frac{10{,}000}{10{,}201}$, which equals nearly $\frac{88{\cdot}3}{84{\cdot}3}$. In case second $\frac{59{\cdot}7}{58{\cdot}7} \times \frac{10{,}000}{10{,}201} = \frac{333}{334}$ nearly. In case third, $\frac{52{\cdot}7}{51{\cdot}7} \times \frac{10{,}000}{10{,}201} = \frac{1348}{1349}$ nearly. $\frac{1}{84{\cdot}3}$, $\frac{1}{334}$ and $\frac{1348}{1349}$ are in accordance with the law I deduced from my own formulæ. From this and the fact that my formulæ give the variation in the attraction of the earth as caused by figure, at any latitude as tested by the pendulum, I have concluded that my investigation must be true or Newton's law of gravitation and the pendulum are both delusive failures. I have no hesitation, then, in deciding, regardless of the criticisms of two distinguished mathematicians and astronomers, that the variation in the attraction of the earth due figure is a part of pure lunar theory, whether or not it meets Newcomb's outstanding column of corrections or his empiricism—with both of which I am now ready to compare my work.

Computations from my formulæ, based on mathematical demonstration and also proven empirically true, make the mean attraction of the earth greater on account of figure by $\frac{1}{334\frac{1}{334}}$ on the moon for a revolution having the inclination of the plane of the moon's orbit to the plane of the equator 18° 18′. This shortens, as compared with standard unit, the time of such a revolution 0·7078 of a second, measured in arc 0·3886″. For a revolution having inclination of the plane of the moon's orbit to the plane of the equator 28° 36′, the attraction is greater by $\frac{1}{334\frac{1}{334}}$, and time is shortened 0·5447 of a second, measured in arc 0·2991″. The difference then in the two revolutions is nearly 0·09″ of arc. The moon in 9·3 years or 124 revolutions passes from one of these limits of inclination to the other. The variation in time from revolution to revolution between these limits is not quite uniform; it is a trifle greater approaching the limit 28° 36′. The difference is, however, too small to affect materially the results given in this paper. Besides the variation in inclination is not quite uniform. If it were the object of this paper to establish a standard measure for the centuries from a period of a few years, it would become necessary to take into account such variations.

In diagram, line A B is 28° 36′ limit, C D 18° 18′, and E F 23° 27′ inclination. Lines perpendicular to these are lines of epochs. The oblique lines, two of which are indicated by the arrows, are lines for tracing the position of the moon as regards inclination or declination.

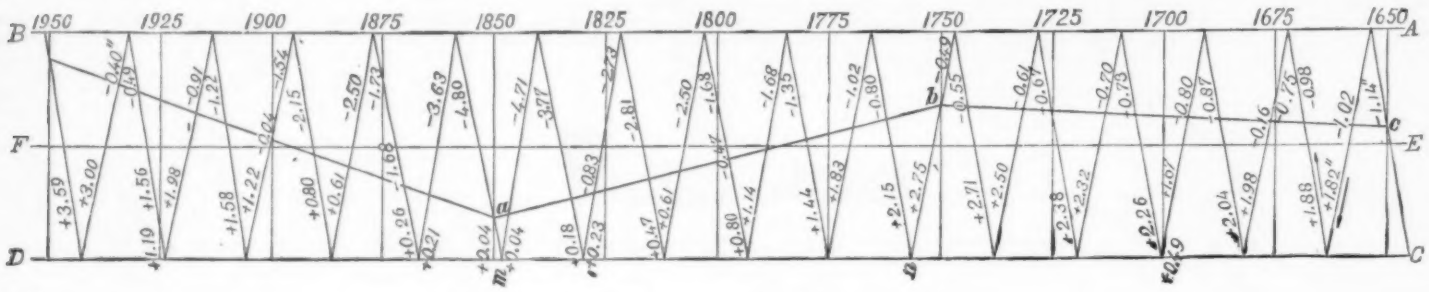
Epochs.	1 Newcomb.	2 Newcomb.	3 Blackstone.	4 Newcomb.	5 Blackstone.
1650	— 6·9″	— 4 7″	— 6·0″	— 2·2″	— 0·9″
1675	— 7·4	— 7·1	— 6·2	— 0 3	— 1·2
1700	— 3·6	— 4·5	— 2·3	+ 0 9	— 1·3
1725	— 0·3	+ 1·2	+ 3·7	— 1·5	— 4·0
1750	+ 6 4	+ 7 3	+ 6 6	— 0·9	— 0·3
1775	+12·5	+11·0	+11·5	— 1·5	+ 1 0
1800	+11·1	+10·4	+11·4	+ 0·7	— 0·3
1825	+ 3 0	+ 4 8	+ 2·7	— 1·8	+ 0·3
1850	— 4 6	— 4·8	— 6·1	+ 0·3	+ 1·3
1875	—15 8	—16·0	—15 7	+ 0·2	— 0·1
1900		—26·4	—22·3		
1925		—33·0	—18·4		
1950		—35 0	—11·3		

The moon was at *a* 1850, at *b* 1750, at *c* 1650, at *m* 1849, and at *n* 1756. If Hansen had taken his standard unit from 1756 to 1849 or some multiple of 18·6 years, he would have had no trouble in adjusting his empiricism between these dates, and outside of them without becoming bewildered by the attractions of Venus. Besides his measuring rod for the centuries would have been more accurate. When Newcomb asks the question: "Is it possible that this correction to the term produced by the action of Venus can really be a result of the attraction of that planet?" he shows suspicion of the wily maiden, yet he courts her favor eighteen times in the empirical formula. The best line on which to adjust his fluctuations due the figure of the earth is E F, taking date about 1863, and any other differing from it any multiple of 18·6 years.

The moon in passing from limit 18° 18′ to 28° 36′ is retarded 5·6′; from 23° 27′ to 28° 36′, 1·4″, and from 23° 27′ to 18° 18′ gains 1·4″. The standard measure of Hansen and Newcomb is from 1750 to 1850. Of course I must figure my column of fluctuations to line *b a* from 1750 to 1850, and to line *c b* from 1650 to 1750, and accordingly for other centuries, in order to compare my work with Newcomb's column of outstanding corrections to pure theory, having secular acceleration 8·8″. Figures on diagram marked + and — show gain or loss in motion of moon in seconds of arc from the standard line *b a*, etc. Any of these numbers can be obtained by solving a simple problem in arithmetical progression.

Column 1 of the above table is Newcomb's column of outstanding corrections to accepted pure theory, having secular acceleration 8·8″; 2 is his computed terms from empirical formula; 3 is my computed terms due to the figure of the earth. I assume 6″ for epoch 1650, and my other terms are obtained by summations of 6″ with figures on diagram. Column 4 is Newcomb's differences, and 5 mine. The limit of error of observation in 1875 as shown by occultations and observations at Greenwich and Washington was 1·7″. The quality of instruments used in 1725 is then a sufficient explanation for the discrepancy at that epoch. It did not require twenty years to prove Hansen's empirical term depending upon eight times the mean motion of Venus minus thirteen times that of the earth a delusion. I venture to predict that the next generation, including that "*liberal supply of astronomers who scan our earth with powerful telescopes*," will pronounce likewise on the empirical term depending upon eighteen times the mean motion of Venus minus sixteen times that of the earth minus the mean anomaly of the moon.

The discrepancy between the secular acceleration of observation and that due to the variation in the eccentricity of the earth's orbit is accounted for at least partially from using an inaccurate measuring unit for the centuries as shown by my investigation. It is no wonder then that astronomers by using different periods of time have disagreed five seconds on the secular acceleration of observation. It is doubtless true that the tides and the contraction of the earth very slowly but quite uniformly affect the length of the day. But such causes are not sufficient to produce fluctuations in the rotatory motion of the earth to account for such fluctuations as are discussed in this paper.



VARIATION IN THE MOON'S MOTION.

AN ESTIMATE OF GEOLOGICAL TIME.

A VERY ingenious attempt to fix a minor limit to the duration of geological time has been made in a paper lately read before the Royal Society by Professor Houghton of Dublin.

It involved, as a preliminary, the demonstration of the untenability of the theory that changes of climate in past ages can be explained by a supposed shifting of the pole. That it is not possible to account for the occurrence of tropical fossils in Arctic regions in this way was shown as follows:

"Let a great circle be drawn, joining Spitzbergen with Cook's Inlet, Alaska; this circle will pass nearly through the North Pole. In order to explain the tropical climate of these two localities, and also of the Parry Islands, the pole must be displaced at right angles to the great circle joining Spitzbergen and Alaska, along the meridian long. 117° E., nearly that of Pekin. The present difference of latitude between New Orleans and Spitzbergen is 45°; so that, in order to make the Arctic regions tropical, we must move the North Pole 45° on the meridian of Pekin, bringing it within three hundred miles to the north of that city. Hence it follows that, during the triassic period, Pekin lay under the North Pole, covered by the polar ice-cap. Let us now consider what the South Pole was doing; it had moved on the opposite meridian, and reached the mouth of the Rio Negro, on the east coast of Patagonia, about 1,000 miles to south-south-east of Valparaiso and the Chilian Andes. Jurassic strata have been found in the Chilian Andes at 34° S., containing the tropical *Ammonites biplex*, which is found also in Alaska, 60° N., and in Europe. This locality lies within 700 miles of the necessary position of the South Pole, and cannot have enjoyed a tropical climate. The proposed alteration of the North Pole is consistent with the occurrence of tropical animals in the Parry Islands, in Spitzbergen and in Alaska; while the proposed alteration of the South Pole would permit tropical animals to exist in New Zealand and New Caledonia; but the occurrence of jurassic ammonites within 700 miles of the South Pole is fatal to the proposed shifting of the axis of rotation, even if that were allowable to the extent required."

By a similar course of reasoning Professor Houghton shows that during the miocene period the North Pole must have been at or near the same place it now occupies. Whereupon he concludes that down to the miocene period, climates depended chiefly on the internal heat derived from the cooling of the earth, and that we may regard the fossils of the Arctic regions as self-registering thermometers, recording the mean temperature of those regions at successive epochs, marking so many fixed points on the earth's thermometrical scale.

In addition to these points on the scale we have the present temperature of the Arctic regions directly observed, and two other temperatures determined by physical and physiological conditions, namely, the temperature of boiling water and the temperature at which albumen coagulates. No stratified rocks could be formed until the earth was cool enough to tolerate water, and no animal life could exist on the earth until it was cool enough to allow albumen to remain uncoagulated. Accordingly we find in the Arctic regions the following successive temperatures:

1.—212° F.....Boiling water.
2.—122° F.....Coagulation of albumen.
3.— 68° F .....Triassic and jurassic periods. (Climate of Gulf of Mexico.)
4.— 48° F.....Miocene tertiary period. (Climate of Lombardy.)
5.— 32° F.....(Climate of Labrador.)
6.— 0° F... .....Present climate.

The interval between the first and second corresponds to the azoic rocks; that between the second and third to the palæozoic rocks; that between the third and fourth to the neozoic rocks. Calculating the relative time required for a cooling globe to pass through the temperatures from 212° F. to 48° F., Professor Houghton finds the lengths of the foregoing periods to be respectively 33, 41, and 26 per cent. of the time preceding the miocene period.

Converting the maximum thicknesses of the several geological strata in Europe into percentages, and comparing them with the percentages of time found from the theory of a cooling globe, Professor Houghton finds the following scale of geological time:

Period.	From Theory of Cooling Globe.	From Maximum Thickness of Strata.
Azoic	33·0 per cent.	34·3 per cent.
Palæozoic.	41·0 "	42·5 "
Neozoic.....	26·0 "	23·2 "
Total....	100·0 "	100·0 "

The agreement between these figures, derived from independent sources, tends, he believes, to justify the principle held by many geologists that the proper relative measure of geological periods is the maximum thickness of the strata formed during those periods.

Extending the calculation founded on the theory of the cooling globe from period 4 to period 5 in the table, the interval of time from the miocene epoch, when the Parry Islands and Northern Greenland enjoyed a climate like that of Lombardy, to the epoch when those regions suffered a climate like that of Labrador, is found to be 32 per cent.; from which it appears that a greater interval of time now separates us from the miocene tertiary epoch than that which was occupied in producing all the secondary and tertiary strata from the triassic to the miocene epoch. This enormous time Professor Houghton believes sufficient to afford ample opportunity for the development of the gigantic mammals, which are commonly supposed to have somewhat suddenly made their appearance on all our continents, and to have disappeared as suddenly.

While believing that the condition of the earth's surface was profoundly different from its present condition during the geological periods when climates depended chiefly on the earth's internal heat, Professor Houghton goes on to estimate the duration of geological time from the present rate of continental denudation. After showing that atmospheric agencies are capable, at present, of lowering the land surfaces at the rate of one foot in 3,000 years, or of silting up the sea bed at the rate of one foot in 8,616 years, he says: "If we admit (which I am by no means willing to do) that the manufacture of strata in geological times proceeded at ten times this rate, or at the rate of one foot for every 861·6 years, we have for the whole duration of geological time, down to the miocene tertiary epoch, 861·6 × 177,200 = 152,675,000 years," the multiplier being the maximum thickness in feet of all known stratified rock. To the time thus obtained we must add about one-third, as already shown, to bring in the period between the miocene and the time when Arctic regions had the climate of Labrador, giving for the whole duration of geological time a minimum of two hundred million years.

Estimates of this sort are instructive, even if not to be implicitly trusted. A peculiar feature of the foregoing is the large portion of time accorded to the more recent geological periods. The method of fixing thermometric points in the earth's history is original and ingenious, but it is evident that the first point, the temperature of boiling water, will not stand for the beginning of stratified rock formation. The liquid of the primeval sea must have been very different from the water of existing seas, so that the temperature 212° F. can hardly be taken as the beginning of erosion and consequent stratification.

THE MISSISSIPPI JETTIES.

IN a letter to Congressman Crittenden, of Missouri, Capt. Eads says: "The jetty channel is now almost as good as the entrance to New York harbor. Larger ships and steamers visit the port of New Orleans than ever before. Ocean freights have been so greatly lowered in consequence that the saving on cotton alone from the port of New Orleans the past season was over $1,600,000. Every intelligent man in Missouri knows that a revolution has been wrought in the grain trade as a result of this deep water. As the channel deepens and commerce adjusts itself to these new conditions the benefits to the producers in Missouri will be still more extensively enjoyed. The permanent improvement of the mouth of the Mississippi operates as a regulator of transportation charges, and thus adds to the value of every bushel of grain grown for export to Europe or for consumption in the Atlantic States; and it also cheapens to the farmer all of his merchandise and other supplies brought from the East."